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FOREWORD

Symposium on **Advances in Educational Technology** (AET) is a peer-reviewed international conference focusing on research advances and applications of combined use of computer hardware, software, and educational theory and practice to facilitate learning. Today, AET is the premier interdisciplinary forum for learning scientists, academicians, researchers, professionals, policymakers, postgraduate students, and practitioners to present their latest research results, ideas, developments, and applications.

AET topics of interest are:

- Artificial intelligence in education
- Augmented reality in education
- Cloud-based learning environments
- Cloud technologies for mathematics learning
- Cloud technologies for informatics learning
- Computer simulation in science and mathematics learning
- ICT in primary and secondary education
- ICT in higher education
- Learning environments
- Learning technology
- Professional training in the digital space
- Massive open online courses
- Methodology of informatization in education
- Modelling systems in education
- Psychological safety in the digital educational environment
- Soft skills development
- STEM education
- Virtualization of learning

This volume represents the proceedings of the Symposium on Advances in Educational Technology, held in Kyiv, Ukraine, on November 12-13, 2020. It comprises 110 contributed papers that were carefully peer-reviewed and selected from 282 submissions. Each submission was reviewed by at least 3, and on the average 3.1, program committee members. The accepted papers present a state-of-the-art overview of successful cases and provide guidelines for future research.

We are thankful to all the authors who submitted papers and the delegates for their participation and their interest in AET as a platform to share their ideas and innovation. Also, we are also thankful to all the program committee members for providing continuous guidance and efforts taken by peer reviewers contributed to improve the quality of papers provided constructive critical comments, improvements and corrections to the authors are gratefully appreciated for their contribution to the success of the workshop. Moreover, we would like to thank the developers of HotCRP, who made it possible for us to use the resources of this excellent and

comprehensive conference management system, from the call of papers and inviting reviewers, to handling paper submissions, communicating with the authors, and creating the volume of the workshop proceedings.

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FULL PAPERS

Online Training of Youth Club Members of Ukraine in Projecting Volunteer Activities in the Conditions of the Spread of COVID-19

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Keywords: Online Education, Volunteer Activity, Volunteer Activity Projecting, COVID-19, Youth Clubs, Volunteers' Projecting Competencies, Volunteer Activity Projecting Readiness.

Abstract: The article deals with the features of the solution of the problem of value and meaning content and the methodology of online training of young people (platforms: Zoom, Moodle, Google Classroom, etc.) to project volunteer actions in the situation of a global coronavirus pandemic. A certificate is submitted concerning the acquisition by youth club members of previous experience of spiritual, patriotic and online design activities. The volunteer project competences framework as a target for relevant online learning is highlighted. The following guiding principles for the development of its content are defined, namely: dominance of online – providing motivation for the activity of young people in the creation of socially significant volunteer projects; priority in the content of the basis of knowledge about information and communication technologies, project method, gerontology, psychotherapy, psycho-hygiene, self-organization, health culture and readiness for volunteer action in crisis conditions, continuity of content of online education of volunteers by means of self-preservation of personality, preventing and overcoming panic, fear and anxiety in a situation; personal orientation and emotionally-sensual saturation of the methodology of online support of subjects of the projecting volunteer activity, etc. Based on these principles, emphasis is placed on the value and meaning potential of the projected experimental special course. The sum of two groups of humanistic methods online-preparation of young people to create volunteer projects is defined, namely: 1) methods of motivation and organization of volunteer project action; 2) methods of stimulation of projecting activity of young volunteers. Attention is paid to the features of the experimental testing of the special course and methodology, and to the criteria for assessing the readiness of youth club members to the create the volunteer projects.

1 INTRODUCTION

The challenges posed by the COVID-19 lockdown (Polhun et al., 2021) have largely affected NGOs, particularly those involved in the volunteer movement. According to a survey conducted by the Democratic Initiatives Foundation in the spring of 2020, more than 80% of respondents confirmed a certain impact of the coronavirus pandemic on public activity. It was also found that the "non-virtual" activity of citizens in creating a real social product had decreased. It's about "what can be done with your hands and feet. But this activity has moved, in particular, to the Internet" (dif.org.ua, 2020). Comparing the current growth rate and scope of civic activity in Ukraine with that in 2014–2015, it can be concluded that the first year of the pandemic did not see a significant surge in volunteerism, for example, there was no large-scale regional movement to fight the coronavirus infection. This was due to the following factors: the "second war", the prompt actions of the state in a crisis situation, the unknown viral danger, its scale, and the COVID-19 information policy, etc.

Our study explored the level of social activity of youth organization members in Ukraine. The COVID-19 pandemic requires finding effective ways to organize the work of youth associations, as well as to radically transform the youth association members' training in providing assistance to people, in particu-

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lar via the Internet.

The effectiveness of IT-based traditional learning is measured primarily by the educational result, which is associated with students' personal and professional development and, consequently, their competent and charitable social activity especially during the global upheavals.

In the context of the COVID-19 lockdown online education becomes the sole and reliable means of training people in active science-based counteraction to the coronavirus pandemic (Semerikov et al., 2020). There is no doubt about the urgency of such training for students in the systems of secondary, high, higher, and postgraduate education, as well as in the systems of non-formal adult education and youth organizations, etc. The volunteer potential of youth organizations remains far from being fully explored.

The least represented in the scientific discourse are the theoretical principles of future volunteers' distance training and online development of youth club members' readiness for the development and implementation of volunteer projects to help people during the lockdown. This should be done to improve youth volunteers' ineffective work in some regions of Ukraine in 2020. Thus, youth volunteer activities were not aimed at normalizing the mental and emotional condition of people with low stress-resistance and increased anxiety and were not based on the achievements of gerontology, gerontopsychology and other sciences when interacting with the elderly, and special psychological, pedagogical and medical knowledge when interacting with children with disabilities. This was due to the young volunteers' lack of competencies in the system planning and implementation of appropriate social work. In fact, there is a contradiction between the social demand for youth organizations' (formal and informal) high competence in providing effective volunteer assistance to people in lockdown and the youth club managers' unpreparedness for online work. The reasons for this unpreparedness, among others, include the lack of scientific requirements and recommendations for the content and methods of young volunteers' online training. Hence, it is imperative to determine the content and methods of young peoples' online training in projecting and implementing volunteer work during the COVID-19 pandemic.

2 RELATED WORKS AND LITERATURE REVIEW

The system of psychological and pedagogical principles and recommendations for fighting coronavirus infection, which is very important for youth volunteering during the lockdown, has been updated in the online manual "Psychology and pedagogy in fighting the COVID-19 pandemic" (Kremen, 2020). Kabysh-Rybalka (Kabysh-Rybalka, 2020) has formulated the psychological principles of volunteer work to check the disease spread and promote hygienic care during the COVID-19 pandemic as well as the rules for safe and effective behavior in the lockdown.

The methodology, theory and improvement of social projecting in the broadest sense have been the subjects of close consideration by a number of scientists in the late twentieth century (Antonyuk, 1986). Particular attention to social projects has been paid by Bezpalko (Bezpalko, 2010) (basic approaches to social projecting and its features; development, text design and implementation of social projects); Pometun (Pometun, 2003) (training young people in social project implementation); Lesnikova (Lesnikova, 2005) (promoting adolescents' social initiative through project activities).

Our study was guided by the theoretical principles of ICT-based learning (Gurzhii and Bykov, 1980; Papert, 1987; Polat, 2004; Robert et al., 2017; Spirin et al., 2019). The aim of the study was to explore the content, principles and methods of distance education with the use of special technologies. Unfortunately, the use of information and communication technologies (ICT) in volunteers' training, especially in conditions of a lockdown, has not received an in-depth coverage in scientific literature. Moreover, the manuals, books and guides, the volunteer movement organizers used in their work even before the pandemic, were few and quite superficial.

Responding to current challenges, educational institutions in Ukraine have to revisit distance learning technologies. According to the Shevchenko (Shevchenko, 2020), there is an urgent need for teachers' training in using special educational programs, such as Moodle (Mintii, 2020), Google Classroom (Bondarenko et al., 2020), Google Hangouts, Microsoft Teams, Skype, Cisco Webex, etc (Pavlenko and Pavlenko, 2021). It should be noted that a number of educational institutions have developed specialized online systems, in particular, based on cloud technologies (e.g., the Electronic Campus (https://ecampus.kpi.ua/) on the basis of the National Technical University of Ukraine "Kyiv Polytechnic Institute named after Igor Sikorsky") to store teaching materials and organize online teachers-students communication (KPI, 2020). Although online education has a number of drawbacks (Polonska, 2020; Morska, 2020; Song et al., 2004), it has also unarguable advantages (Cojocariu et al., 2014; Singh and Thurman, 2019; Vlasenko et al., 2020). However, the distinctive features of young volunteers' online training have not attracted Ukrainian researchers' attention yet.

Aim: to discuss the theoretical basis, content, tools and results of the experimental online program aimed at developing Ukrainian youth club members' readiness to project volunteer activities during the COVID-19 pandemic.

3 RESULTS AND DISCUSSION

3.1 Background Information on the Work of Youth Territorial Clubs Falcons before and at the Outbreak of the Pandemic

The network of youth territorial clubs Falcons (hereinafter clubs Falcons) began operating in 2015 as a statutory activity of the public organization Love. The clubs were set up in many schools in a number of regions of Ukraine.

The main goal of the youth territorial clubs Falcons is the promotion of spiritual and patriotic education of adolescents and youth by means of various educational programs (e.g., the Cossack Magazine and The Pages of Eternal Stories programs). The main values that are fostered in the "falcons" include faith in God, love for Ukraine and respect for its history, language, and culture, brotherhood and sisterhood, high motivation for social work in the community, purity of body, soul and intersex relations, respect for the elderly, mercy for the needy, and patience for the little ones. The club members' leading activity is planning, organizing and conducting social projects during the year. Before the pandemic, the results of the work were presented and evaluated in the form of a team competition at the annual Falcon Games, where the winners were determined and future projects were presented to apply for a grant. During the summer, club members were involved in holding summer camps for young local community members, during which the "falcons" developed such important character traits as purposefulness, resilience, leadership, responsibility, and communication. In July, the most active club member took part in a summer falconry camp, where they could continue their patriotic, civic and spiritual training.

The COVID-19 pandemic posed serious challenges to the Falcons clubs. The letter of the Ministry of Education and Science of Ukraine of April 4, 2020 "On the organization of the educational process in out-of-school educational institutions during the lockdown" recommended to develop measures for partial use of telework and, if possible, for conducting educational classes, including, hobby groups, by means of online technologies (MON, 2020).

Until March 2020, social projecting was part of weekly meetings of club members with their leaders or mentors. The clubs' work was built on the close cooperation between the falcons, as well as with the administrations and students of educational institutions, and the residents of territorial communities. However, in mid-March 2020, after the imposed lockdown, the activities of the Falcons clubs stopped. The lockdown was felt by absolutely all public organizations. As a matter of urgency, most organizations that focused on direct contact with the population had to limit their activities.

Members of the Love NGO immediately refocused on the volunteer movement. Thus, during March-April 2020, a pilot project Second Wing – Food Delivery as part of the local volunteer initiative Do Not Be Indifferent was launched to deliver food and medicines to the elderly who are at risk of COVID-19 in the town of Irpin. Under this project, more than 100 families were visited by the Falcons club members. In addition to delivering food and medicines, the falcons had short talks with carereceivers on the basic safety rules to reduce the risk of infection. Besides, the elderly were given religious support by pastors of the local Christian community. As part of the Second Wing project, in May 2020, young people from the Kyiv-city Falcons club visited a social hostel for graduates of a specialized boarding school for visually impaired children. The hostel residents were given material (food and antiseptics) and psychological assistance (friendly communication and answers to the questions about safe life in crisis conditions).

Unfortunately, the morbidity rate in Ukraine did not improved, it even worsened, which required better project activities of club members as volunteers and their greater competence in this matter.

3.2 The 2020 Falcons Club's Zoom-based Project, the Camp Maker

This project was created in order to develop club members' project activity experience. After all summer events were canceled in the spring of 2020 due to the spread of COVID-19, club members were invited to take part in a special project.

The management of Love NGO chose a convenient and easy-to-use Zoom platform to develop, organize and implement The Camp Maker project, which was aimed at involving club members in planning the activities of a day-camp, which has become traditional in recent years. While previously the falcons had been active participants and helpers in day-camps, that time they were invited to author the event program made up of the camp mission, planned activities, their schedule, team organization, etc.

All participants were divided into three large teams. Each team had two weeks to prepare and present a special project to the judges. There were three such projects, so the team-members worked together for 6 weeks. The teams had to prepare:

1. *The camp's business card*. This task included group work on the name, advertisement, logo, and the general concept of the future camp. It was also important to substantiate the choice.
2. *The camp's organization*. This task included counselor work schedule, a daily routine, and an event plan.
3. *The camp case*. The teams had to prepare a draft advertising campaign in the local community, the list of necessary equipment and materials for various clubs (stations), and a camp estimate.

During two weeks, team members met on the Zoom platform to work together. Each team was given a free hand in choosing a teamwork format. Some teams preferred group-work, others were divided into threes to perform different portions of the task, while still others chose leaders to lead the work. Once a week, online meetings of all campers were held for general communication, data exchange, and interim reports.

The best project received a grant in accordance with the camp's budget, and its authors were given an opportunity to organize a similar camp in the future. The Zoom platform has proven itself effective in this work.

The results of the Falcons club's project activities allowed determining certain advantages of distance training compared to the traditional training. These advantages included trainees' high viral safety through individual and/or mixed work, a higher level of trainees' activity in solving tasks, better opportunities for trainees' mastering new technologies, a better opportunity to unify falcons from different clubs and regions of Ukraine, a good way to bypass direct personal contact restrictions, and a higher level of club members' psychological comfort.

3.3 The Theoretical Basis for Solving the Problem under Consideration

The following definitions have been proposed based on the following scientific principle: the character of a particular activity is the basis for understanding the content of individuals' training and readiness for it. In our case, we first analyzed the character of pandemic-specific volunteerism, the structure of social projecting, and the online trainers' activities. Besides, Dyachenko and Kandybovich (Dyachenko and Kandybovich, 1976) considered individuals' psychological readiness, both general and situational, for an activity as a unity of individuals' motivational, cognitive and emotional characteristics.

Youth club members' online training in projecting volunteer activities during the COVID-19 pandemic is a holistic educational process carried out under the guidance of a distance counselor by means of special tools (Zoom, Moodle, Google Classroom, Google Docs, etc.). The main aim of this training is the development of trainees' readiness to create and implement socially significant projects to help people in avoiding a viral disease.

The appropriate readiness, which includes moral, psychological and practical components, is a complex quality of a young person and an indicator of his/her ability to mobilize their vital and axiological potentials and self-create (self-educate) for spiritual and moral purposes in order to act adequately in the pandemic.

The volunteers' holistic practical readiness to create a socially significant project in the pandemic is provided by their basic project competencies, which include: the ability to develop a logical organizational structure of the volunteer project; the ability to take the initiative and generate innovative ideas to help people during the pandemic; the ability to generate humanistic volunteer projects; the ability to develop a project based on the information about survival rate and economic downturn of people at risk; the ability to provide develop projects to help the community members adapt to the pandemic restriction; the ability to use different work forms, methods and means to get the best results from the volunteer efforts; the ability to find the necessary project resources and to plan and supervise the project's implementation.

Trainees' volunteer project-making readiness can be developed using the systemic, synergetic, axiological, competence, andragogical, personality, activity, and phenomenological approaches.

Theoretical and methodological analysis and synthesis allowed formulating the following principles of online development of youth club members' readiness for volunteer activities projecting during the COVID-19 pandemic: online motivation of young people for creating socially significant volunteer projects; the focus of young volunteers' online education on communication technologies, project method, gerontopsychology, psychotherapy, psychohygiene, creativity, health culture and willingness to volunteer during the pandemic; the regular update of the content of volunteers' online education by new information on personal self-preservation and on panic, fear and anxiety management; the well-balanced analyses of volunteers' experience in projecting programs to help children with disabilities, the elderly and people infected with coronavirus; provision of personal online support for the youth club members' volunteer activities projecting.

Based on the above-mentioned principles, we have developed a 36-hour-long online training course called "Volunteer Activities Project as a Response to the Pandemic" made up of the following modules:

1. Personal meaning of projects to help people during the COVID-19 pandemic;
2. Essential minimum knowledge as values and means of development of volunteer activities projects;
3. A volunteer as a people's mental health harmonizer and an anxiety-/fear-management counselor during the COVID-19 pandemic;
4. Projecting volunteer assistance for the elderly and children with disabilities during the COVID-19 pandemic;
5. Medical and psychological support for projecting serious COVID-19-patients care programs.

The content of the first module is aimed at developing young people's motivation for projecting volunteer activities during the pandemic. Trainees' online volunteer activities projecting motivation using special techniques is the transformation of trainees' knowledge about the terrible consequences of coronavirus infection and ways and means of helping people into the trainees' personal values and as a result the development of the trainees' personal meanings and aims of appropriate volunteer projects.

The topics of the second module have been selected according to the importance of specific knowledge for quality projects to fight the pandemic. The second-module topics include: "The main competencies of a volunteer as an assistant to people during the lockdown", "The essence of social projects; the project method and its use in volunteerism", "Psychological support for volunteers during the lockdown", "Basic theoretical knowledge in valeology, gerontology and gerontopsychology", "The leading principles of sanitary and hygienic science, psychotherapy and psychohygiene", "Essential characteristics of volunteers' distance learning in the pandemic", "Basic volunteers' self-education and self-development technologies".

The third module aims at developing trainees' skills to control their own psycho-emotional state and to teach children and adults to preserve and harmonize their mental health as well as manage their pandemic-related anxiety and fear. The module trains volunteers to online-teach children and adults to distract from anxious thoughts using exercise, physical activity, and/or developing their sense of beauty/aesthetic taste. Optionally, volunteers can master special psycho-emotional management and resilience development techniques.

The fourth and fifth modules should develop club members' pandemic-specific volunteer activity readiness. This readiness includes club-members':

1) help to care-receivers' in their safe satisfaction of their needs, such as:
   (a) timely and trouble-free reception of pension;
   (b) reception of food, medicine and hygiene products from supermarkets and pharmacies;
   (c) direct, in particular, online contacts with family doctors, relatives and friends;
   (d) doing hard household work;
   (e) raising the general culture by online means, etc.;
2) ability to provide safe medical assistance to people who are self-isolated at home with a serious form of COVID-19 infection;
3) ability to attend to children with special needs, in particular, visually impaired children.

The methodology of the special online training used the following person-oriented and emotion-developing techniques: a special interactive lecture, emotionally-colored information (about the dangers of coronavirus infection, essentials of the technology of personal self-development, etc finding the personal meaning of specific volunteer activities; person-oriented approach to the educational material; development of trainees' positive attitudes towards volunteer activities (positive feelings towards quality projects, knowledge of their own moral, emotional and physical potentials, willingness to help people, self-education and self-development, etc.); trainer-trainee cooperation in creating bright images-standards of youth readiness for volunteer activity; infecting trainees with positive emotions when assessing their academic progress.

The online training project method has been updated to include volunteer project development exercises. The volunteer project activity development techniques included special online situations of spiritual and moral choice, group discussions, lockdown-specific volunteer project competition, cognitive and assessment games, online classes conducted by counselors and practitioners (psychologists, teachers, psychotherapists, epidemiologists, pediatric ophthalmologists, etc.).

3.4 Experimental Verification of the Effectiveness of the Special Training Course “Volunteer Activities Project as a Response to the Pandemic”

The special online training course was tested for effectiveness at youth territorial clubs Falcons (Kyiv, Kharkiv, Rivne, Vasylkiv, Gostomel, and Skvira). The sample included 72 trainees who had some experience in volunteer educational and/or social work.

The club members were offered special literature on social projects and had to carry out a set of tasks to develop relevant project competencies. The trainees' self-educational and self-development activity was in line with their project work, in particular, the online project “The Social Project Maker”, which was two months long (with general, team and individual meetings three times a week) and used the ZOOM platform. The trainees developed different components of the integrated social project launching competence. This required the trainers to be creative lecturers and discussion moderators as well as encouragers of trainees' innovative ideas. The trainers listened to and initiated discussions of the trainees' reports on volunteer activity projects, interviewed the trainees and gave them creative tasks, combined person-oriented lectures with case-studies on volunteer activity projects.

For example, D. G. Gryshchuk, besides giving open lectures called “Basic competencies of a volunteer as an assistance to people during the pandemic” and “The essence of social projects, the project method and its use in volunteerism”, etc.), shared his rich practical experience of running successful volunteer projects, such as “The mission of service to children is to help orphans” (Donetsk region, 2004–2006), “Good House” (Donetsk, 2011–2013), and “Second Wing – help migrants” (Ukraine, 2014–2015). Other trainers and instructors of the Falcons club and the Love NGO also shared their experience in increasing volunteers' community activities and in changing social values of volunteering into personal values. During the discussions, the trainees most often asked questions about the motivational component of volunteering, the psychological, psychotherapeutic and medical care to certain groups of the population. Often, such questions were answered by the invited specialists (epidemiologists, psychologists, psychotherapists and others).

It should be noted that the Vasylkiv Falcons Club (Kyiv region) and the Kyiv Falcons Club were the winners of the 2018 and 2019 Falcons Games, respectively, in the Best Social Project nomination. At the initial stage of the online training, only one of the three draft projects submitted for evaluation was based on the pandemic-relevant sanitary standards, but none of them contained a clear analysis of the sanitary-epidemiological situation in the neighborhood as a factor behind volunteerism to help those at risk from the pandemic.

Some of the tasks the members of the experiment had to carry out were aimed at developing collective projects. The most conceptually interesting individual volunteer projects were those related to the psychological and material support for the families of the deceased, the assessment of urgent needs of and the delivery of food, medicine and hygiene products to people with disabilities. At the project presentation stage, one of the Falcons teams stressed the importance of a free course to teach the elderly to make online utility payments, make online drug orders, top up cell phones online, and communicate with family members online. Another project team presented several online courses adapted for learning at home, city libraries and/or social centers. One winning project used a special program of communication with social services and local library administration. Another winning project, called SuperSTAR, estimated the purchasing of four computers and special programs to improve online learning. The project, whcich proved to be effective, was run for two months, and helped 30 elderly people to develop their basic Internet skills.

The You are Not Alone project presented to the contest featured a fundraising program made up of a number of special events (presentations, motivational videos, printed materials) to raise money for hospitals and specialized social institutions (rest homes, hospices, boarding schools, psycho-neurological clinics, etc.). The raised money was meant for buying oxygen concentrators to help people with coronavirus. This project also was aimed at providing targeted assistance to people who stayed at home through the purchase and delivery of food and medicines, and walking pets, etc.

At one of the video conferences, the participants of the online training noted the benefits of the information on mental health preservation during the COVID-19 pandemic and anxiety- and fear-management techniques (Velykodna and Frankova, 2021). The trainees also stressed that their knowledge of the sanitary and hygienic principles and the essentials of psychotherapy and psychohygiene improved their project competencies.

Although online training had a number of advantages, it was not devoid of certain shortcomings, which were:

- low level of psychological comfort because of inadequate audio and/or visual perception of other team-members during online team work. Almost every second project participant felt uncomfortable, tired, and irritated after 40 minutes of online communication as a result of poor lighting, technical failures, and inability to see and/or hear other team-members.
- difficulties in moderating a large number of participants in online discussions, brainstorming and other organizational activities. For example, the ZOOM platform does not allow seeing more than 25 people on a single screen, which makes it difficult to respond promptly to the conference participants' remarks and questions, which lowers the quality of heuristic learning. The situation with smartphones is even worse as they fit no more than four conference participants into the screen.

The experiment participants' volunteer activity projects were assessed according to: the degree of the projects' humanistic orientation (focus on satisfying the needs of the most vulnerable community residents), the projects' general concept (the way volunteerism is visioned during the pandemic), the scientific substantiation of the proposed volunteer actions (i.e basing the lockdown-specific volunteer activities on the relevant principles of psychology, psychotherapy, valeology, gerontology, and gerontopsychology; the project teams' ability to build their work with children with special needs on the principles of medicine and pedagogy, etc.); the projects' technological character (a clear description of the stages, content, forms, methods, means, and algorithm of volunteers' social activities); the projects' logical structure (definition of the problem(s) to be solved by the volunteer project; presentation of the ideas about the long-term outcome of the project; setting specific goals and objectives for the near future; description of volunteer services to meet the requirements of people from risk groups, people with special needs and COVID-19 patients; description of the projects' resources; the projects' schedule: the terms of and persons responsible for the realization of each project task; youth club management's control over volunteers' actions); the projects' realism (compliance of the projects' financial, staff and material resources with the possibilities of the youth organization; the projects' sensitivity to the peculiarities of the regional social environment).

The evaluation of the projects presented by the youth club members allowed determining the levels of their readiness to run volunteer activities projects during the pandemic, which were high, sufficient and low, before and after their attending the special online course (see table 1).

As can be seen from the table, the training course increased the total number of volunteers with sufficient and high levels of readiness to run volunteer projects during the lockdown by 47.2%, in particular, the number of those with high readiness increased by 8.3%, while the number of those with low readiness decreased by 47.2%.

The obtained results show that the Love club volunteers have well-developed project competencies and can run high-quality social projects in crisis situations. All the experiment participants became deeply aware of their volunteer assistance's role in helping their community residents in the lockdown, which was demonstrated by their strong training and project-making motivation. In particular, the vast majority of trainees (54 people) developed the ability to set social projects' goals and objectives and determine their organizational structures for at-risk groups. 57 club members (79.1% of the total number of trainees) in their volunteer programs demonstrated knowledge of ways to provide practical assistance to the elderly, children with special needs, and COVID-19 patients.

The trainees had difficulties in generating original conceptual ideas for their pandemic-specific volunteer activities, in developing online/telephone methods for maintaining the mental health of retired people and children with special needs as well as in describing the psychological and sanitary support given online or over the telephone to COVID-19 patients in self-isolation.

4 CONCLUSIONS

1. Youth organization members' distance training during the pandemic is considered as a unique social phenomenon and a mechanism of project support for volunteerism, which is an important way to fight the pandemic. Under certain conditions, distance training is an important factor in increasing youth club members' productive social mobility as a result of increasing their willingness to help people in difficult living conditions.

Table 1: Distribution of experiment participants by their readiness to project volunteer activities during the COVID-19 pandemic.

Readiness levels	% of volunteers before the experiment	% of volunteers after the experiment
Low	59.7	12.5
Sufficient	37.5	76.4
High	2.8	11.1

2. Young people's online training in projecting volunteer activities during the pandemic is effective if: 1) trainees and trainers know how to use information and communication technologies for educational purposes; 2) there are good resources for conducting effective online-classes; 3) the content of distance training is based on the scientific principles of formation of volunteers' readiness for work under lockdown restrictions in order to promote safety and mental and physical health of people at risk;
3. The results of young people's online volunteer training can be helpful for: a) the development of scientific ideas about the features of social projects and training young people in project running under crisis circumstances; b) the improvement of online education (in the context of youth organization members' training); c) forecasting education policies in unfavorable social conditions.

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The Psychological Safety of the Educational Environment of Ukrainian Higher Education Institutions in a Pandemic: Empirical Data of a Comparative Analysis of Participants' Assessments Studying Online

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Abstract: This paper highlights the problem of ensuring the psychological safety of participants of the educational process in the mass transition to distance learning, caused by the complex conditions of our time and the specific features of the digital environment in the COVID-19 pandemic. The study demonstrates the results of a comparative analysis of students' assessments studying online in a pandemic, the peculiarities of the psychological safety of the educational environment and its impact on students studying online in a pandemic. Also, this paper reveals the insufficient tendency to decrease the level of psychological safety of the educational environment for a significant number of subjects. There are statistically significant differences in the peculiarities of the psychological safety of participants in the educational process as to gender, age, and status. The survey of participants in the educational process presents the results as to their attitude to the peculiarities of learning under the conditions of the COVID-19. They testify to the deterioration of psychological safety in the educational environment of higher education institutions, and, accordingly, the subjective well-being of participants in the educational process in a pandemic. There was a decrease in the number of respondents with a positive attitude to distance learning and a willingness to work exclusively online. The study displays the expediency of full-time and distance learning as such, which is optimal for the organization of the educational process and contributes to the psychological safety of participants in the educational process.

1 INTRODUCTION

Today's challenges, voluntary social isolation, uncertainty, stress, and the threat to health caused by the spread of COVID-19 (Velykodna, 2021) have shifted people's emphasis in public, social, professional, scientific, educational, and religious life toward online services (Tkachuk et al., 2021).

These and many other difficult life situations necessitate adaptation to new conditions and expect special requirements for their safety at all levels of life. Thus, educational institutions around the world have switched to distance learning to create safe conditions for students and necessary measures for a full-fledged educational process in connection with the COVID-19 pandemic (Velykodna and Frankova, 2021). According to UNESCO with an increasing number of states, provinces and even whole countries closing institutions of learning as a response to the COVID-19 pandemic, almost 70% of the world's students are not attending school (Commonwealth of learning, 2020).

Changing the traditional (full-time) form of distance learning has revealed gaps, problems, anxiety,

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unpreparedness for such, unexpected challenges in users of social networks.

Forced distance learning requires not only the organization of the educational process in quarantine and the use of traditional teaching methods but also to provide specific resources for e-learning, master information tools and be able to use them depending on the understanding of the goal so that each person feels psychologically protected (safe) in the modern Internet environment and in general in the information space. Therefore, the problem of the psychological safety of a person who studies online in a pandemic becomes especially relevant.

Psychological safety is a kind of safety awareness based on the psychological climate of the educational process in educational institutions (Ming et al., 1504, pp. 433-440). This is especially important in times of social changes, the rapid development of information technology, and the possibility of using various means of influencing human consciousness. In this context, a psychologically safe educational environment is a condition for the personal growth of the participants of the educational process through their interaction, independent from the manifestations of psychological violence; reference significance and involvement of each subject in designing and maintaining the psychological comfort of the educational environment; a humanistic orientation, etc (Bondarchuk, 2018b).

2 LITERATURE REVIEW

Psychological safety is a basic need for safety, "a kind of sense of confidence, safety and freedom that removes fear and anxiety, in particular, it contains a feeling that a person meets current and future needs" (Maslow et al., 1945, pp. 21-41). Psychological safety involves the reduction of interpersonal risk, which necessarily accompanies uncertainty and change (Schein and Bennis, 1965; Siemsen et al., 2009), readiness to "get a job or express oneself physically, cognitively and emotionally during role performances", the ability to "refuse and defend one's personal" (Kahn, 1990, pp. 692-724).

Nowadays complex conditions and the specific features of the digital environment in the COVID-19 pandemic, which is a favourable basis for psychological violence, cyberbullying, manipulative influences, caused the problem of psychological safety of participants in the educational process in the mass transition to distance learning, which attracts particular attention. In particular, a new form of bullying – *cyberbullying* is a form of behaviour that consists in sending messages of an aggressive and offensive nature using new information and communication technologies (Internet, and mobile phone). There are many factors and theories of bullying, the most famous of which is the sketch theory of (Olweus, 2004, pp. 5-17), where the existence of typical characteristics of "victim" and "aggressor".

Other forms of cyberbullying are the "hacking" actions aimed at harming the "victims"' personal computers (hacking and changing passwords, damaging personal websites, etc.). All these damages determine the presence of specific features of such "high-tech" bullying in comparison to a traditional one.

Firstly, constant hostile actions are inessential, as, for example, one-time damage to the victim's website with the addition of offensive information may have a longitudinal effect (many network users will read the message).

Secondly, the factor of physical strength, important in cases of ordinary (contact) bullying, is insignificant. The intellectual abilities and technical skills of the aggressor come to the fore in this case.

Thirdly, there is no direct communication between the "aggressor" and the "victim". So the "aggressor", for example, does not observe the reaction of his/her "victim" and the outcomes of the actions. Bullying via the Internet allows the "aggressor" to remain anonymously and turn the situation of persestageion into a kind of "masquerade" (Hinduja and Patchin, 2010, pp. 206-221).

Therefore, the psychological safety of all the participants in the educational process studying online in a pandemic is a prerequisite for their psychological well-being and psychological health.

We single out such scientific investigations of recent years, which together with the above serve theoretical and methodological basis for research.

We have developed the conceptual provisions on the content of the psychological safety of the individual in general (Edmondson, 1999; Edmondson and Lei, 2014; Gartner, 2019) and its role in the process of knowledge exchange in virtual communities, in particular (Commonwealth of learning, 2020). We consider safety as a key psychological characteristic of the educational environment (Baeva, 2020), while the psychologically safe educational environment as a condition for the personal growth of the participants of the educational process through their interaction, independence from the manifestations of psychological violence; reference significance and involvement of each subject in designing and maintaining the psychological comfort of the educational environment; a humanistic orientation, etc.

The research examines the specifics of psychological safety as one of the most important factors of work in the virtual environment (Edmondson, 1999; Breuer et al., 2016; Goller and Laufer, 2018; Rozovsky, 2015).

The following study has analysed: the features of distance learning under the conditions of self-isolation as to the COVID-19 pandemic (Bailey-Findley, 2019); the peculiarities of the use of diverse digital educational resources and online learning tools in the educational process (Kartashova et al., 2018; Bondarenko et al., 2018); the specifics of the organization of effective work of remote virtual teams online (Pilar and Middlemiss, 2019; Shyshkina and Marienko, 2020), management aspect in distance learning (Kapucu and Salih, 2020, pp. 8-27); the possibility of obtaining the psychological safety in such teams (Congelos, 2020; Costello, 2020) and approaches of ensuring the psychological safety in a crisis (Clark, 2020).

Besides, most students and teachers of higher education institutions had little experience with online tools, information technology before the SARS-CoV-2 (COVID-19 [coronavirus disease 2019]) pandemic. Today's challenges have caused a shock in society – a threat to human health from COVID-19, economic downturn, the transition to distance learning, job losses, social support, business closures and more.

Distance learning is not the same as online learning. Real online learning takes place on digital platforms designed for this purpose, often with personalized content for each student and options for using their chosen digital tools. Online learning promotes different types of learning preferences, provides flexibility and uses quality indicators online. But under COVID-19, distance learning for the student community did not include any of these functions but instead provided a set time to listen to teachers' lectures via Zoom or Google Meet (Weir, 2020, p. 54). Moreover, pre-coronavirus online training programs may not be as effective without the support of teachers and a personal learning structure.

The teaching staff needs pedagogical support for distance learning and proper education on the systems used and preparation of the content of academic disciplines (Kapucu and Salih, 2020; Shokaliuk et al., 2020), mastering new technologies and their use in parallel with their previous experience and beliefs (Hinduja and Patchin, 2010; Büyükbaykal, 2015).

After all, digital competence is now an essential competence that modern man needs for personal realization and development, employment, social integration and active citizenship (European Commission, 2018; Moiseienko et al., 2020; Kuzminska et al., 2019).

In Ukraine, scholars are currently conducting the research, which relates mainly to psychological care and psychotherapeutic practice in a pandemic in various spheres of public life (Kremen, 2020). For instance, the well-known scientific work "The world of life and psychological safety of human under conditions of social change", carried out by a team of scientists led by M. Slyusarevsky at the Institute of Social and Political Psychology during 2000-2017, which contains extremely valuable scientific results. However, authors of the work naturally could not predict the course of events related to the COVID-19 pandemic and, accordingly, conduct basic research in this aspect, the results, in particular, determine the ways of the rise of the individual's psychological safety under the conditions of social changes.

Despite numerous studies, the problem of psychological safety of the educational environment in general and students studying online in a pandemic, in particular, attracts attention. As a result, the desire for safety is a basic human need, an important factor in the self-realization of the individual in professional and personal life and a condition for a full life of the individual (Ryan and Deci, 2001).

Consequently, the most important goal of the educational institutions is to ensure the psychological safety of the educational environment for students studying online in a pandemic, integrating the effective use of ICT in the educational process, updating the psychological and pedagogical science. At the same time, it is essential to fully promote the change of education for a sustainable future by strengthening critical thinking, communication, cooperation and creativity in youth (Semerikov et al., 2020).

The *goal* of the article is to present the features of the psychological safety of the educational environment and their impact on students studying online in a pandemic. *Objectives of the study* – to find out:

1) peculiarities of psychological safety of the educational environment for participants of the educational process online;
2) participants' attitudes in the educational process (students and teachers) to the peculiarities of learning under the conditions of the COVID-19 pandemic;
3) to carry out a comparative analysis of students' assessments studying online in a pandemic regarding the change of the psychological safety of the educational environment of higher education institutions

3 METHODS

For studying the features of the psychological safety of the educational environment and their impact on students studying online in a pandemic, was the method of I. Baeva "Psychological safety of the educational environment" (Baeva, 2020) modified by O. Bondarchuk (Bondarchuk, 2018b,a), which allowed measuring the level of psychological safety of the individual in the educational environment.

The author's questionnaire carried out the study of the peculiarities of the psychological safety of the educational environment for the participants of the educational process and their attitude to the features of learning under the COVID-19 pandemic condition. Afterwards, the respondents answered the questions on various aspects of learning, such as:

1. Does the educational institution contribute to your psychological safety under the conditions of the COVID-19?
2. Is distance learning comfortable for you?
3. What form of training is optimal for you?
4. What information tools do you use in the educational process in the context of the COVID-19 pandemic? etc.

The empirical study implemented online through Google Forms. This allowed prompting feedback from participants in the educational process. From our previous work experience, Google Forms "not only determines the nature of the relationship between the participants of the educational process and the degree of satisfaction with them, and the socio-psychological climate as an indicator of organizational culture but also makes the appropriate management decisions and forecast situations in the educational environment; promptly intervenes and makes appropriate adjustments to the educational process; specifically, plans work on the relevant problem in the institution of higher education; creates conditions for comparing one's assessment of the pedagogical staff's activity with an independent assessment" (Bondarchuk et al., 2020) and surveys the level of this influence.

The usage of Google Forms and other information and communication resources in education allows you to: easily and quickly adapt to new requirements of distance education; monitor the quality of education; create an optimal environment for educational services; and understand human behaviour in the social environment, life cycles and interactions between biological, psychological, social-structural, economic, political and cultural factors of the educational process (Balakhtar, 2018, pp. 93-104).

There is the widespread usage of Google Forms for conducting various surveys, including for testing the level of knowledge acquisition; as a test platform, and test results are stored in the Google Cloud (Petrenko et al., 2020).

Surveying or testing via Google Forms allows not only to significantly increase the level of research or testing, to reach a large number of students but also to reduce the labour costs of data processing for the teacher. After all, it is achievable to create an unlimited number of surveys, questionnaires, tests and invite an endless number of respondents. Tasks may vary in different spheres of the discipline and include questions on a specific topic or general topic or even an entire course. Besides, Google-forms allows you to create a form with different elements or types of questions where each can be made mandatory or optional. While creating a form, you may change the order of questions and choose different designs for their design. The link to the form is generated automatically after its creation.

To better monitor the students' academic achievements and, in turn, to join the well-designed learning goals, the distance learning assessment affords noteworthy chances during the educational process.

To clarify the dynamics of indicators of psychological safety of the educational environment of higher education institutions during the year in a re-survey Google Forms was supplemented with questions:

1. If you compare your sense of psychological safety and comfort in an educational institution today and a year ago?
2. If you compare your attitude to distance education now and a year ago?
3. If you compare your psychological well-being (including mental health) now and a year ago?

Respondents had to choose from the following answer options:

a) significantly worsened
b) has worsened
c) practically has not changed
d) has improved
e) significantly improved

Besides, we were interested in aspects related to the experience of psychological security and well-being in online learning, in particular:

1. What measures, actions did you take for your own development during the quarantine period?
2. Are you ready to fully switch to online learning?

The research used the content analysis with the focus on determining the relationship between psychological safety and well-being of participants in the educational process, and their knowledge and practical activities in the context of distance learning. Yuriy Fedkovych Chernivtsi National University and SHEI "The University of Educational Management" respondents were invited to participate in the study, acquainted with the purpose, scope and process of the study; received permission from the teaching staff, who agreed to participate. Information sheets about the research and a questionnaire in the Google Forms were sent to the participants of the educational process via e-mails. The survey was conducted at the beginning of the previous year (March, I stage), and at the end of 2020 (December, II stage) a re-form was sent to the addresses specified in the generalized Excel sheet.

Responses came from almost all respondents in the first sample, who responded positively to the situation of re-survey. This, in particular, is evidenced by the instructions in a large number of sent response forms such as: "I was glad to help", "Thank you very much for your interest in our psychological state", "Thank you for the opportunity to participate in the survey" etc.

Participants in the educational process received information from research staff on unclear issues or situations by e-mail. This way ensured that the participants in the educational process gave clear answers to the questions asked.

Statistical data processing and graphical presentation of results was carried out using the SPSS 17.0.

4 ANALYSIS OF THE RESEARCH RESULTS

4.1 Social and Demographic Characteristics of the Research Sample

The main group of respondents consisted of 174 people – representatives of socionomic professions of Yuriy Fedkovych Chernivtsi National University and SHEI "The University of Educational Management", whose professional activities include "spiritual and moral maturity", "increased moral responsibility" and "values to people's lives", "willingness to face changing challenges" and "uncertainty" (Taormina and Sun, 2015). The respondents were divided into groups according to:

- gender (37.9% male & 62.1% female);
- age (up to 20 years – 15.5%, 20-30 years – 41.4%, 30-40 years – 15.5%, 40-50 years – 15.5%, over 50 years – 12.1%);
- place of residence (village – 41.4%, town – 58.6%);
- status (student – 75.9%, teacher – 24.1%) (table 1).

The separation of groups depending on the sex of the respondents was due to the gender features of the perception of psychological safety of the environment in different spheres of public life revealed in the research (Callahan, 2004). In particular, gender dissimilarity may have a more negative impact on the psychological safety of men with an increased number of women in working groups than on the psychological safety of women with an increased number of men in workgroups (Tsui et al., 1992). Accordingly, gender types contrasted by birth, so we determined the gender stereotypes by positive or negative prejudgments (Skitka and Maslach, 1990; Petrenko et al., 2020). We believed that psychological safety allows you to fully engage in work responsibilities without fear of negative consequences for your status, career or image (Kahn, 1990).

We also considered the age of the educational process participants in the context of their perception of the environment psychological safety. Hence, according to the researchers (Safety FOCUS, 2019), there is a different perception of various aspects of psychological safety of different generations and, equally, age groups.

Based on the results of our study, we revealed differences in the psychological safety of the educational environment depending on the status of participants in the educational process (teacher, student). This case research question was how stable the detected trend is. Moreover, we have found similar trends in other studies, such as Nembhard and Edmondson (Nembhard and Edmondson, 2006) of the psychological safety of the environment and professional status.

We also determined the peculiarities of assessing the level of psychological safety by the place of the respondents. We assumed that there are more risks in the city to ensure the psychological safety of the educational environment than in the countryside. The basis for this assumption was the study (Gilemkhanova, 2019), which dealt with such differences.

Another controlled variable was the basic education of respondents (social and humanitarian or natural and mathematical. In this context, we counted on both our practical experience and Tsvyetkova (Tsvyetkova, 2014) study, which indicates a difference in the value and meaning of teachers of differ-

Table 1: Groups of the respondents.

Groups of the respondents	Frequency	Valid Percent
Gender		
female	108	62.1
male	66	37.9
Age		
up to 20 years	27	15.5
20-30 years	72	41.4
30-40 years	27	15.5
40-50 years	27	15.5
over 50 years	21	12.1
Place of residence		
village	72	41.4
town	102	58.6
Status		
student	132	75.9
teacher	42	24.1
Basic education		
social and humanitarian	123	72.4
natural and mathematical	47	27.6

ent specialities. The author emphasizes that teachers of socio-humanitarian profile have conformist values (education, self-control), and more dependent on socio-political ideology; teachers of natural sciences and mathematics are based on individualistic values (independence, boldness, rationalism), independence of thinking from political events, focus on rigidly fixed laws, patterns, principles (Tsvyetkova, 2014).

Based on these considerations, the following research hypotheses were formulated.

H_1: The psychological safety of the educational environment of the higher education institution and, as a result, the subjective well-being of the participants in the educational process in a pandemic have deteriorated.

H_2 Participants in the educational process are different: gender (H_{3-1}), age ($H3-2$), place of residence (H_{3-3}), status (H_{3-4}), basic education (H_{3-5}) differ in the levels of experience of psychological safety of the educational environment.

H_3: The number of respondents with a positive attitude towards distance learning and a willingness to work exclusively online has decreased.

4.2 Dynamics of Indicators of Psychological Safety of the Educational Environment for Participants and Their Subjective Well-being of the Educational Process Online

Under the condition of psychological safety, a person perceives the world around him/her as emotionally safe or free from emotional pressure (Taormina and Sun, 2015, pp. 173-188). People who feel psychologically protected do not perceive the world and other people as a threat. A sense of psychological safety creates a pleasant interpersonal relationship and allows you to take risks to achieve high life goals (Afolabi and Balogun, 2017, pp. 247-261).

Quarantine causes a crisis for society, and, in particular, education. It is well-known that during the crisis it is difficult for people (as well as for educational institutions) to fully realize their expectations and competencies. The experience of distance education in higher education institutions shows that the level of these competencies is very different. Hence, we, as a society, who strive for better higher education, have to invest wisely, strengthen universities, promote creative ideas and find resources for their implementation. It is a key prerequisite for their qualitative transformation.

The effectiveness of a modern educational institution is measured not only by the quality of education but also by students' safety and teachers' safety. According to the results, this study in Ist stage indicated the low and the average levels of psychological safety of the educational environment, i.e. in 40.1% of socionomic professions (10.3% and 25.9%, respectively), 63.8% of the respondents showed the high and very high levels (table 2).

Table 2: Levels of psychological safety.

Levels of safety	I stage, %	II stage, %
low	10.3	11.8
average	25.9	33.5
high	50.0	39.4
very high	13.8	15.3

The obtained results determine the nature of the interaction, communication of the respondents of the educational process, the possibility of meeting and developing the needs of the individual in a sense of safety, maintaining and improving self-esteem, recognition, the formation of a positive self-concept, self-actualization, etc.

Instead, the second stage of the study (at the end of last year) deals with the relative deterioration of psychological safety indicators for participants in the educational process: a decrease in the number of participants who rated psychological safety as high from 50% to 39.4% and an increase in the number of participants who rated safety as average (from 25.9% to 33.5%) and low (from 10.3% to 11.8%). At the same time, the share of respondents who noted the level of psychological safety of the educational environment as very high (from 13.8% to 15.3%) (differences at the level of a weak trend, $p = 0.14$) increased slightly.

The obtained results are consistent with the participants' assessment of the level of psychological safety of the educational environment compared to a year ago (table 3). Respondents were asked to determine whether the psychological safety of the educational environment had changed for them during the year.

Table 3 shows that less than half of the respondents (42.9%) note that the level of psychological safety has not changed.

One-third of respondents (29.4%) indicate an improvement, and 6.5% – a significant improvement in the level of psychological safety. Instead, every fifth participant in the survey indicates a decrease in the level of psychological safety – deterioration (12.4%) or significant deterioration (8.8%). There have been changes in the subjective well-being of participants in the educational process in a pandemic, as evidenced by their answers to the question "If you compare your psychological well-being (including mental health) now and a year ago..." (table 4).

As in the previous case, only less than half of the participants (47.1%) indicate that their psychological well-being (including mental health) has practically not changed. 16.5% of respondents indicate an improvement, and 2.4% – a significant improvement in their well-being.

On the other hand, one-third of the participants in the educational process noted that their psychological well-being (including mental health) deteriorated during the year (21.2%) or significantly deteriorated (12.9%). The Spearmen rank correlation coefficient revealed a direct, statistically significant correlation between the dynamics of changes in the psychological safety of the educational environment and the subjective well-being of participants in the educational process.

We established that the deterioration of psychological safety of the educational environment is accompanied by a decrease in the level of subjective well-being of respondents, which is a confirmation (as in previous studies (Bondarchuk, 2018b; Baeva, 2020)) of the relationship of these phenomena. Thus, the results indicate a partial confirmation of hypothesis H_1 that the psychological safety of the educational environment of higher education institutions and, as a consequence, the subjective well-being of participants in the educational process in a pandemic has deteriorated.

4.3 Socio-demographic and Organizational-professional Peculiarities of Psychological Safety of the Educational Environment for Participants of the Educational Process Online

By the purpose and objectives of our study, the truth of hypothesis H_2 about the differences in the levels of experience of psychological safety of the educational environment by participants in the educational process depending on their socio-demographic (gender, age, place of residence), and organizational-professional (status, basic education) characteristics was tested.

According to the results of ANOVA, the research revealed statistically significant differences in the peculiarities of psychological safety of the educational environment of participants in the educational process depending on gender and professional status (figure 1, $p < 0.01$).

Figure 1 shows that male feel more psychologically protected than women, and students feel more psychologically protected than teachers. Similar de-

Table 3: Levels of the psychological safety in the educational institution today and a year ago.

Levels of safety today compared to a year ago	Percent
significantly worsened	8.8
worsened	12.4
practically has not changed	42.9
improved	29.4
significantly improved	6.5

Table 4: Levels of the psychological well-being (including mental health) today and a year ago.

Levels of the psychological well-being compared to a year ago	Percent
significantly worsened	12.9
worsened	21.2
practically has not changed	47.1
improved	16.5
significantly improved	2.4

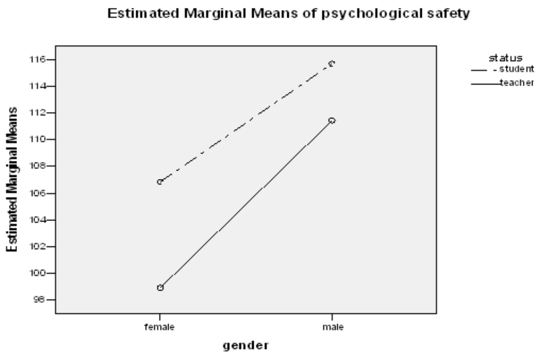

Figure 1: The peculiarities of psychological safety of the educational environment of participants in the educational process depending on gender and professional status.

pendencies were confirmed at repeated research, at the end of the year. This situation, in our opinion, reflects, on the one hand, the positive trends in the implementation of the student-centred approach, and on the other hand, the negative trends associated with the ambivalent position of the teacher in modern Ukrainian society.

At the same time, the picture of experiencing psychological well-being at the end of the year turned out to be somewhat different.

From the data given in table 5, it follows that the number of students for whom well-being has significantly deteriorated is higher than for teachers (15.0% and 5.4%, respectively). On the other hand, those students for whom the level of psychological well-being has improved are significantly less than teachers (12.0% and 32.4%, respectively) (statistically significant differences were found by criterion χ^2, $p<0.05$).

We attribute these results to the pandemic situation – a reasonably large number of respondents became ill with COVID-19 (fortunately, there were no fatalities among them), so it had a negative impact on their mental state. Based on our experience of interacting with such students, some of them even refused to turn on their video cameras in class, citing poor appearance and the fact that they have not yet fully recovered from the disease.

For many of them, the state of the disease came as a shock: after all, the media constantly spread information about the risk of the disease, especially for the elderly and, mainly, the retired ones, respectively, they did not perceive the situation as threatening to themselves. This situation, in our view, raises the issue of the adequacy of media coverage in general and in a pandemic in particular.

It is noteworthy that at the level of secondary education of Russian secondary school pupils and teachers revealed a different trend: teachers of secondary education found a higher level of psychological safety than students (Baeva and Bordovskaia, 2015). The latter, according to researchers may indicate that the psychological safety of the educational environment for the teachers and the students can be determined by various factors (Baeva, 2020, p. 94).

Also, the age-related characteristics of the experience of psychological safety by participants in the educational process were confirmed and even became more pronounced. At the first stage, at the beginning of the year.

Furthermore, according to the age of participants in the educational process, 2 categories of respondents feel more protected. Firstly, it is young people (up to 20 years old) – mostly students, which indicates, in our opinion, the gradual implementation of the student-centred approach in higher education. Secondly, senior responds over the age of 50 (mostly teachers who have acquired professional status, have

Table 5: Levels of the psychological well-being (including mental health) of students and teachers today and a year ago, $p < 0.05$.

Levels of the psychological well-being compared to a year ago	Percent	
	students	teachers
significantly worsened	15.0*	5.4*
worsened	20.3*	24.3*
practically has not changed	50.4*	35.1*
improved	12.0*	32.4*
significantly improved	2.3*	2.7*

degrees and titles) and are well established in their educational institution (differences in the level of trends, $p = 0.103$).

The second phase of the study at the end of the year draws attention to a certain decrease (compared to previous data) in levels of psychological safety for young people (up to 20 years old) and senior responses over the age of 50 with the general preservation and strengthening of the previously identified trend. (figure 2, $p<0.01$).

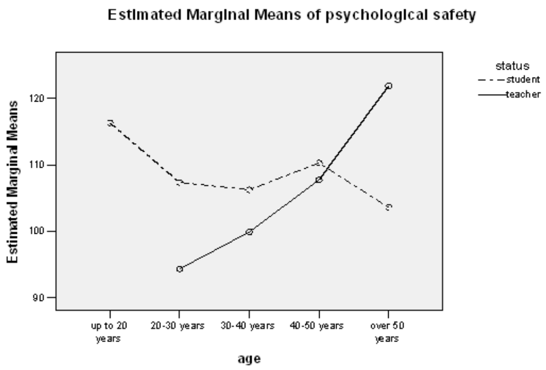

Figure 2: The peculiarities of psychological safety of the educational environment of participants in the educational process depending on age and professional status.

Furthermore, according to the results of ANOVA, the results showed the peculiarities of the experience of psychological safety by participants in the educational environment depending on their place of residence (figure 3, at the level of a weak trend, $p = 0.17$). Figure 3 shows lower indicators of psychological safety for participants in the educational process living in the city. This situation is especially noticeable in students. We clarify this state of affairs precisely by the specifics of the place of residence and, in particular, by the artificial restriction of a significant number of contacts to which those who live in the city are accustomed.

For participants from villages, this situation is less emotional due to fewer direct contacts for villagers. In the rural type of life, a certain rhythm of life is stricter;

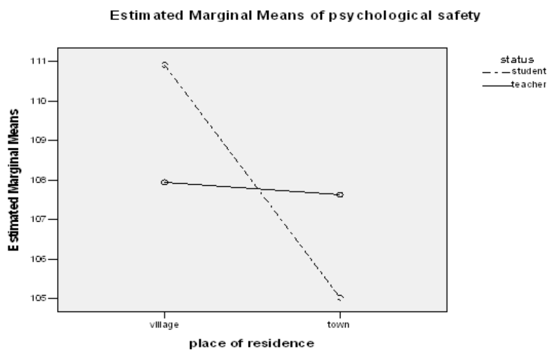

Figure 3: The peculiarities of psychological safety of the educational environment of participants in the educational process depending on age and professional status.

there is less choice of occupations, a narrowed space of communication.

Our assumption about features of psychological safety of educational environment for participants of educational process with various education was confirmed (figure 4, at the level of weak tendency, $p = 0.16$).

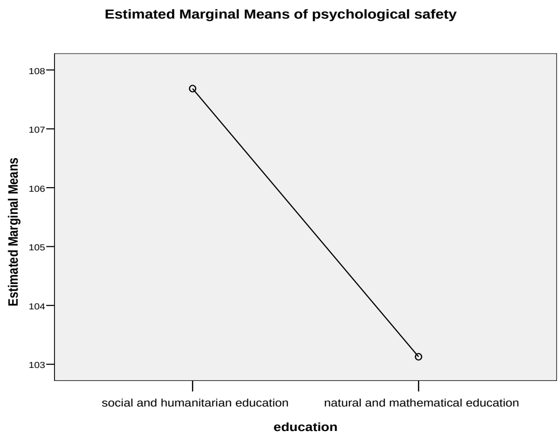

Figure 4: The peculiarities of psychological safety of the educational environment of participants in the educational process depending on base education and professional status.

Figure 4 displays that in the case of the social and humanitarian orientation of the participants in the educational process, the psychological safety of the educational environment is perceived higher than for representatives of natural and mathematical education.

The obtained results are consistent with the data of Gilemkhanova (Gilemkhanova, 2019) according to which, there is an impressively higher level of the rigour of the risk of socio-psychological safety in the educational environment in cities and towns than in the village. The researcher notes that the contextual factors have lower links with the socio-psychological safety index, as contrasted with other personal points. The practical value of this study is that this information helps to objectively assess the risks of social and psychological safety in a particular educational environment. It is also necessary to take timely preventive measures in the most stressful institutions in terms of psychological safety. Increasing psychological prevention work with students with different risk indicators is more relevant (Nembhard and Edmondson, 2006; Hinduja and Patchin, 2010).

A detailed analysis of the results revealed both the most problematic and relatively favourable areas of psychological safety for participants in the educational process, which are somewhat different for teachers and students (tables 6, 7).

Thus, according to the results of the first stage students feel protected in the following aspects of their educational activities: continuous improvement of professional skills (54%), development of abilities (54%), the opportunity to express their points of view (48%), ask for help (46.8%).

According to the second section, the picture has changed somewhat: the students' positive assessment of what has increased work in a higher education institution requires constant improvement of professional skills (73.7%).

Instead, the benefits of the educational environment in terms of interpersonal relationships have diminished significantly. Thus, according to students, the opportunity to express their point of view has significantly decreased (24.8%). It also became smaller the opportunity to ask for help (39.8%) (table 6).

Instead, according to the results of the first stage students feel psychologically unprotected because of the negative mood at work they do (21.5%); public humiliation: by students (19.9%), teachers (22.3%), administration (23.8%), being ignored by the administration (16.6%) and threats from the administration (11.9%).

At the end of the year, the situation in this context somewhat eased, but new threats to the psychological safety of the educational environment appeared, in particular, protection from an unfriendly attitude of students decreased, the low level of which was found in 8.3% of students compared to 1.5% at the beginning of the research (table 6).

Similar dynamics of views on various aspects of psychological safety of the educational environment is found in teachers. Thus, the results of the first stage teachers feel more psychologically safe in the constant improvement of professional skills (45.8%), the development of their abilities in the process of work (33.3%), and getting pleasure from their activities (41.7%).

Instead, according to the second section, the picture has changed: teachers' positive assessment that the work in a higher education institution requires constant improvement of professional skills has increased significantly (from 45.8% to 97.3%), also, that the development of their abilities in the process of work (from 33.3% to 83.8%). In our opinion, this is explained by the need to master new digital technologies to perform their duties well in the conditions of mass transition to distance learning. Instead, the mood in a teachers 'work that they do worsen (from 41.7% to 35.1%) (table 7).

However, according to the results of the first stage they are psychologically unprotected from public humiliation as a devaluation of the teacher's professional achievements, groundless criticism in the presence of others, especially by colleagues (39.8%), administration (27.3%); threats from students (31.3%), colleagues (43.8%), administration (25%). Besides, there are problems with the manifestation of initiative activity (37.5%), expressing their point of view (25%), receiving some help (25%), taking into account their problems and difficulties in professional activities (25%).

At the end of the year, these threats to teachers mostly decreased, in particular, they were psychologically unprotected from public humiliation, especially by colleagues (32.4%), administration (10.8%); threats from colleagues (37.8%), administration (21.6%). Besides, there are problems with the manifestation of initiative activity (8.1%), expressing their point of view (5.4%), receiving some help 10.8%). Besides, there is an increase in experience psychologically unprotected from public humiliation by students from 24.9% to 35.1%.

At the same time, there are trends for new challenges in the context of the psychological safety of the educational environment: the threat that the administration will force teachers to do anything against them will increase from 1.5% to 13.5%. A possible explanation for the established results may be a much smaller number of direct contacts of teachers with colleagues, on the one hand, and a decrease in

Table 6: Some questions about the psychological safety of the high education students.

Problem areas of psychological safety	The low level of safety, %	
	I stage	II stage
The mood at your work that you do	21.5	21.1
Protection from public humiliation:		
by students	19.9	8.3
by teachers	22.3	6.2
by the administration	23.8	11.3
Protection from being ignored by the administration	16.6	9.8
Protection from threats from the administration	11.9	7.5
Protection from unfriendly attitude of students	1.5	8.3
Relatively favourable areas of psychological safety	**The very high level of safety, %**	
	I stage	**II stage**
Working in your educational institution requires constant improvement of professional skills	54.0	73.7
The work you have to do helps to develop your abilities	54.0	50.4
The opportunity to express your point of view	48.0	24.8
Opportunity to ask for help	46.8	39.8

Table 7: Some questions about the psychological safety of the high education teachers.

Problem areas of psychological safety	The low level of safety, %	
	I stage	II stage
Protection from public humiliation:		
by students	24.9	35.1
colleagues	39.8	32.4
by the administration	27.3	10.8
Protection from threats from		
by students	31.3	37.8
by teachers	43.8	37.8
by the administration	25.0	21.6
Relationships with colleagues	37.5	8.1
The opportunity to express your point of view	25.0	5.4
Opportunity to show initiative, activity	37.5	8.1
Opportunity to ask for help	25.0	8.1
Taking into account personal problems and difficulties	25.0	10.8
Protection from the fact that the administration will force you to do anything against your will	2.7	13.5
Relatively favourable areas of psychological safety	**The very high level of safety, %**	
	I stage	**II stage**
Working in your educational institution requires constant improvement of professional skills	45.8	97.3
The work you have to do helps to develop your abilities	33.3	83.8
The mood in your work that you do	41.7	35.1

the possibility of direct influence on students, on the other. In the latter case, the student may be formally present at the lesson, but for various reasons “hide” behind the author, which accordingly complicates the ability to control the quality of his inclusion in the lesson (table 7).

From the data of table 7, it follows that for teachers of higher education it is possible to state an imbalance between relatively favourable and problematic areas of psychological safety of the educational environment towards the latter.

Besides, the problem of compensation for those socio-psychological mechanisms of influence on the educational activity of students, which were involved in the educational process in full-time form and, accordingly, direct interpersonal communication.

In general, it is stated that the hypothesis that the participants in the educational process are different: gender (H_{3-1}), age (H_{3-2}), place of residence (H_{3-3}), status (H_{3-4}), basic education (H_{3-5}) – differ in the levels of experience of psychological safety of the educational environment as a whole confirmed.

The received information on social-demographic and organizational-professional features of psychological safety of participants of the educational environment it is expedient to consider at the organization of their psychological support and support in the conditions of training online.

4.4 Survey of Participants in the Educational Process on Their Attitude to the Peculiarities of Learning under the Conditions of the COVID-19 Pandemic

Thus, to study the peculiarities of learning and the attitude of participants to it, we sought to learn about the sources, online resources where participants in the educational process obtain information.

Accordingly, the respondents – representatives of socionomic professions use the Internet search engines, specialized resources, sites, archives, databases via the Internet (13.3%), social networks (Viber (16.7%), Facebook (13.3), Instagram (6.7%), Telegram (9.9%), Skype (13.3%), and media (27.8%) to obtain information. It is clear that, as the distinguished reviewer noted, Internet is used in order to search for information using search engines, specialized resources, sites, archives, databases via the Internet. But we were interested in the psychological aspect of the fact of using the Internet, in general. We understood psychological humiliation as public humiliation by colleagues and administration as a devaluation of the teacher's professional achievements, groundless criticism in the presence of others. In further editing, if necessary, we can further detail the content of the psychological safety indicators.

Participants in the educational process use e-books (27.8%), gadgets (33.4%), and personal computers (16.7%), laptops (22.1%). A small part of the respondents uses various means (16.7%).

The educational process manages mainly through such online services as Zoom (33.4%), Google Meet (16.7%), BigBluButton (3.3%), Moodle (13.3%) and Google applications (23.3%), which allows organizing conferences and webinars for different numbers of users and speakers.

At the end of the year according to the survey the respondents – representatives of socionomic professions use the Internet (33.3%), social networks (Viber (9.7%), Facebook 14.3), Instagram (16.7%), Telegram (19.9%), Skype (2.3%), and media (3.8%) to obtain information.

Participants in the educational process use e-books, NAES repository (14.4%), videos recommended by the Ministry of Education and Science (13.4%), gadgets (23.4%), and personal computers (26.7%), laptops 25.1%). A small part of the respondents uses various means (13.7%).

The educational process manages mainly through such online services as Zoom (33.4%), Google Meet (16.7%), BigBluButton (3.3%), Google Class (22.2%), Moodle (13.3%), Google Jamboard (11.1%), and Google applications (53.3%), which allows organizing conferences and webinars for different numbers of users and speakers.

Thus, during the quarantine period, teachers and students are forced to use Internet resources. Quality online classes require the teacher to improve personal skills in working with online sources and platforms, as well as to master new information resources (Asana, Google Docs, Wiki, Dropbox, Google Jamboard, Kahoot, Miro board, Dashboard, Mentimeter etc.).

Besides, to positively influence the level of student achievement in the conditions of distance learning, it is necessary to create a wide variety of test tasks. After all, in contrast to the classroom conditions during practical classes, the student online may: prepare for as much time as he needs; pass about a hundred tests of one topic, which cover all its aspects and allow him/her to consolidate the lecture material; get a good knowledge of a particular topic; and, accordingly, to higher performance.

We also studied what new opportunities in the context of learning were noted by the participants of the educational process during the quarantine period. At the same time, according to criterion χ^2 statistically significant differences in the choice of classes of students and teachers were stated (table 8, $p < 0.05$).

Table 8 shows that teachers, in general, were more active than students in choosing constructive forms of activity during quarantine and forced isolation. Accordingly, while engaging the process of education during the quarantine period, teachers have higher activities in mastering the online course (40.5%) and passing internship (13.5%) and reading a lot (16.2%) than students (23.3%, 6.8% and 10.5% respectively). Thus, students have higher activities in the following actions: passing advanced training courses (32.3%), increasing the amount of communication on social networks (11.3%) and doing nothing but current affairs (15.8) than teachers (21.6%, 2.7% and 5.4% re-

Table 8: Features of activity of participants of educational process during the quarantine period.

What measures, actions did you take for your own development during the quarantine period?	Percent	
	students	**teachers**
mastered the online course	23.3	40.5
passed internships	6.8	13.5
passed advanced training courses	32.3	21.6
read a lot	10.5	16.2
increased the amount of communication on social networks	11.3	2.7
did nothing but current affairs	15.8	5.4

spectively).

Thus, the most important activity for teaches is to master the online course, whereas for students – to pass advanced training courses. Despite this, the less important for teachers is to increase the amount of communication on social networks, whereas for students – to pass internship.

We paid special attention to studying the attitude of participants in the educational process to the peculiarities of learning in the context of the COVID-19 pandemic. We asked them to answer questions on various aspects of learning.

Thus, we were interested in how much the educational institution contributes to the psychological safety of participants in the educational process. Only a quarter of respondents believe that the educational institution partly facilitates (25%). But a third of respondents (27.1%) indicates the opposite, i.e. does not contribute to the creation of psychological safety in participants. At the same time, almost half of the respondents (47.9%) reflect stress caused by quarantine. Importantly, distance learning cannot fully provide the ability to express emotions, feelings, and the ability to listen and hear, convince each other, sensuality, experience, the formation of moral, spiritual, and value spheres of the participants. Half of the participants in the educational process (52.1%) are satisfied with the form of distance learning. However, 54.2% of people consider mixed full-time and distance learning to be the optimal form for them (table 9).

The results of the study on the educational process participants' attitude to the peculiarities of distance learning under the COVID-19 conditions are of interesting. According to the results of the first stage, the participants mostly feel the psychological safety from the educational institution under the conditions of the COVID-19 "partly facilitate" (47.9%), then "on the contrary, under conditions of quarantine it causes stress" (27.1%) and "facilitate" (25.0%). However, the results have changed a bit at the end of the educational year according to the second stage, i.e. the participants of educational process feel more safety psychologically from the educational institution under the conditions of the COVID-19 "facilitate" (78.4%), "partly facilitate" (13.5%), and "on the contrary, under conditions of quarantine it causes stress" (8.1%).

Moreover, the results of the table 9 show the state of being comfortable during distance learning, i.e. of the first stage the participants of educational process mostly feel "comfortable" themselves (52.1%) than "uncomfortable" (37.5%) and "Not quite so, I would like more F2F communication" (10.4%). Still, the results of the second stage display the participants of the educational process have the same attitude to the state of being "comfortable" and "uncomfortable" (35.1%). Furthermore, the third section of table 9 due to the optimal form of training demonstrates chiefly equal results for the first and second stage, i.e. the highest state is "mixed full-time and distance learning" (54.1% and 51.4% respectively), then for the first stage there is the sequence of preferences: "distance learning online" (37.5%) and "full-time learning" (8.3%), but for the second stage there is no sequence, just the equal results for both preferences (24.3% each).

Thus, the results show the appropriate change of the educational process participants' attitude to the peculiarities of distance learning under the COVID-19 conditions. Hence, there takes place the participants' desirability of full-time learning alike distance learning. Its absence not only causes negative emotions of participants in the educational process but, also, negatively affects their academic success in the future (Kuhfeld et al., 2020).

The researchers note that the missing school for a prolonged period will likely have impacts on student achievement. Furthermore, students likely are returning this fall with greater variability in their academic skills.

Taking into consideration the research about students, who suffered from Hurricane Katrina (Harris and Larsen, 2019), it is urgent to make all the comfortable conditions without learning loss for the participants of the educational process during COVID-19. Additionally, it is vital to empower educational

Table 9: The participants' attitude of the educational process to the peculiarities of distance learning under the COVID-19 conditions.

The participants' attitude	I stage, %	II stage, %
Does the educational institution contribute to your psychological safety under the conditions of the COVID-19?		
on the contrary, under conditions of quarantine it causes stress	27.1	8.1
partly facilitate	47.9	13.5
facilitate	25.0	78.4
Is distance learning comfortable for you?		
uncomfortable	37.5	35.1
not quite so, I would like more F2F communication	10.4	29.7
comfortable	52.1	35.1
What form of training is optimal for you?		
distance learning online	37.5	24.3
full-time learning	8.3	24.3
mixed full-time and distance learning	54.2	51.4

leaders to protect the participants of the educational process and "researchers to make urgent evidence-informed post–COVID-19 recovery decisions" (Kuhfeld et al., 2020, p. 562).

Without a doubt, there are numerous studies and practical experience of distance learning, which testifies to its advantages. Thus, in recent years, Massive Open Online Courses (MOOCs) opportunities have been widely discussed as they are "one of the most prominent trends in higher education in recent years" (Baturay, 2015, p. 427). It is a well-known trend for distance education which gathered all the education process participants all over the world to share the educational content on the online platforms around the US and Europe, like Coursera, EdX, Udacity, Udemy, Iversity, MiriadaX, and Futurelearn (Baturay, 2015, p. 428). These courses are generally formed, set, and led by academics through open source web platforms (Siemsen et al., 2009; Universities UK, 2013; Panchenko and Muzyka, 2020).

Moreover, the changes in communication technologies play a significant role in social life and create new opportunities in the field of education. Nowadays, the most meaningful change in communication technologies is the communication structure of people and organizations.

Thus in the communication medium is evident the interactivity. There are several advantages of communication technologies under the conditions of COVID-19 or quarantine periods, i.e. establishing intensive communication through new media technologies and social media; all the participants of the educational process may receive the information transmitted to a large community; students have an ability to gain the knowledge of communicating by e-mail other than social media; distance learning platform is considered as a place in the life-long learning process; and of urgent, it is the chance to create new opportunities in the field of education (Büyükbaykal, 2015, pp. 636-640).

But the fundamental difference in the current situation is the compulsory nature of distance learning within formal education through quarantine safety measures. That is why, in our opinion, the question "Are you ready to fully switch to online learning?" a relatively small number of respondents answered in the affirmative. At the same time, statistically significant differences in the answers of students and teachers were stated according to criterion χ^2 (table 10, $p<0.05$).

Table 10 shows that only 33.1% of students and 18.9% of teachers expressed a willingness to switch entirely for online learning. A vital number of respondents are supporters of mixed, full-time and distance learning (34.6% of students and 54.1% of teachers). At the same time, almost a fifth student (18.9%) and every third teacher (33.1%) oppose the full transition to online learning.

The research pointed out the statistically significant differences in the peculiarities of psychological safety of the educational environment for adherents of forms of learning according to the results of ANOVA (figure 5, $p < 0.05$).

So, figure 5 shows that adherents of full-time and mixed forms of learning feel themselves as the most secured, whereas adherents of distance learning perceive the educational environment as much less psychologically safe.

The obtained results are confirmed by the assessment of the participants of the educational process of their readiness to completely switch to distance learning (figure 6, $p < 0.05$).

Table 10: The participants' readiness of the educational process to fully switch to online learning.

Are you ready to fully switch to online learning	Percent	
	students	teachers
yes	33.1	18.9
no	18.9	29.7
mixed form of education	34.6	51.4

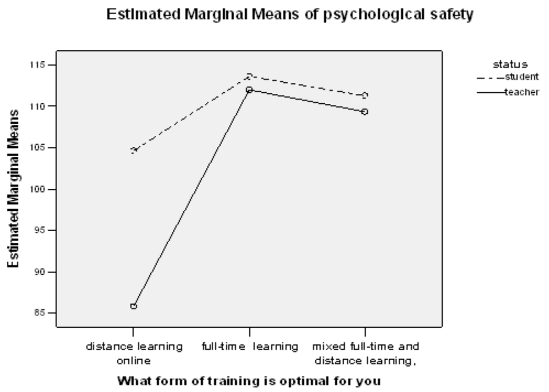

Figure 5: Peculiarities of psychological safety of the educational environment for adherents of various forms of education ($p < 0.05$).

Figure 6 shows that for those participants in the educational process who are not ready to completely switch to online learning, the indicators of psychological safety of the educational environment are the lowest.

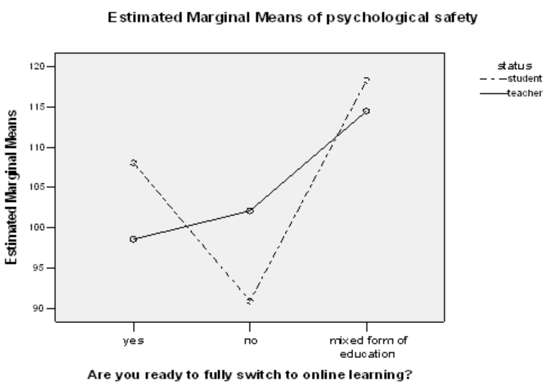

Figure 6: Peculiarities of psychological safety of the educational environment up to the willingness to fully switch to online learning ($p < 0.05$).

Also of interest are the results of the analysis of the dynamics of psychological well-being of participants in the educational process – supporters of various forms of education over the past year (figure 7, $p < 0.01$).

Figure 7 displays that it is possible to state positive

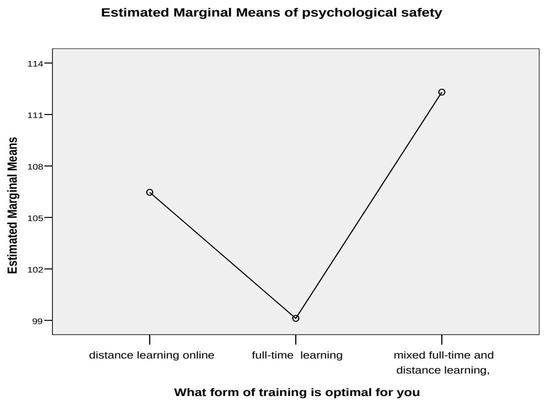

Figure 7: Dynamics of psychological well-being during quarantine for supporters of other forms of learning ($p < 0.01$).

dynamics of psychological well-being during quarantine at those participants of the educational process who are supporters of the mixed form of training which experience they partially had last year. Significantly lower levels of psychological well-being were found in supporters of distance learning and, especially, full-time education ($p < 0.01$).

Therefore, it is not surprising that the results of improving the psychological well-being of those participants in the educational process who due to certain circumstances have changed their attitude to distance learning over the past year in a positive direction (figure 8, $p < 0.01$).

Figure 8 shows that with the improvement of the attitude to distance learning, the indicators of psychological well-being of participants in the educational process also increase. In contrast, for those whose attitudes toward distance learning have deteriorated, psychological well-being also decreased ($p < 0.01$).

Such results testify to expediency and extreme urgency of appropriate psychological support of participants of the educational process whose relation to distance learning in the conditions of quarantine restrictions has worsened recently.

The obtained results indicate the possibility of using a mixed form of education in the future, as the knowledge, skills and abilities acquired in the COVID-19 pandemic are relevant and in demand for a sustainable society, support for 21st-century skills de-

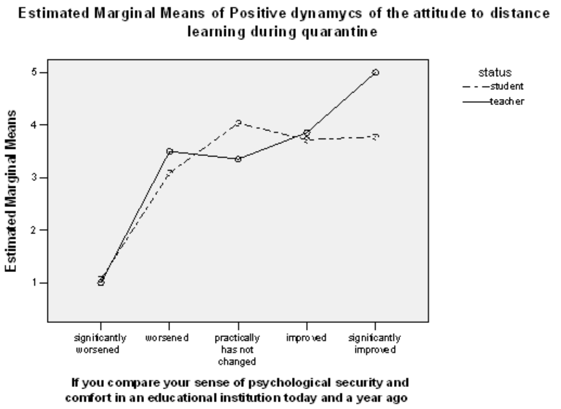

Figure 8: Correlation between positive dynamics of psychological well-being during quarantine and attitude to distance learning ($p < 0.01$).

velopment through ICT and others (Semerikov et al., 2020).

On the other hand, it seems appropriate to develop a programme of psychological support for participants in the educational process of learning in a pandemic. Such a programme, as evidenced by "the evaluation of the deferred efficiency of the formative psychological impact in the educational environment" (Baeva and Shakhova, 2020), may also help increase the psychological security of the educational environment.

5 CONCLUSIONS

The results of the comparative analysis revealed that the psychological safety of the educational environment of the institution of higher education, respectively, and the participants of the educational process affects their subjective well-being. At the same time, the subjective well-being of participants in the educational process in a pandemic has deteriorated. Besides, differences in the experiences of psychological safety of the educational environment among participants in the educational process were revealed: male feel more psychologically protected than women, and students feel more psychologically protected than teachers; lower indicators of psychological safety for participants in the educational process living in the city; psychological safety of participants in the educational process of social and humanitarian orientation is higher than for representatives of natural and mathematical education, etc.

The research has confirmed the hypothesis of reducing the number of respondents with a positive attitude to distance learning and willingness to work exclusively online.

The results of the study revealed an insufficient level of psychological safety of the educational environment for numerous participants in the educational process. On the one hand, the study has established the peculiarities of psychological safety as to gender (women are more protected than men (gender inequality), age (students (up to 20 years old) and older students (over 50 years old) are more vulnerable) – mostly teachers who have acquired professional status and are well established in status (teachers feel less protected than students).

On the other hand, the results indicate the attitude of participants in the educational process to the peculiarities of learning, where half of the participants in the educational process are satisfied with the distance form of learning in a pandemic. The lack of open communication and feedback provokes a negative attitude of a significant number of respondents.

The most optimal and, at the same time, psychologically safe forms of learning for most participants are mixed full-time and distance learning. This requires a change in policy in higher education, the implementation of appropriate reforms that will facilitate the mastery of information tools. Presently, in the educational process exist full-time, mixed and full-time distance learning. Taking into account the nowadays situations, a mixed form of education belongs to the future.

We consider the development and testing of a program of psychological support for participants in the educational process in full-time and distance learning in a pandemic for further work.

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Strategic Branches of Economic and Managerial Training of Principals in Ukraine using Business-simulations

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Keywords: Entrepreneurship Education, Business-Simulation, Business Tournament, Business School.

Abstract: The main topic of this articles focused on ways of introducing and using of modern simulation into education of youth 14-19 ages in schools, colleges, institutes and universities of post-socialistic countries (for example Ukraine). Actuality of this theme is determined by need of increasing of economic literacy, activity and responsibility of Ukraine's society for really realization of economic reforms. All persons, especially our youth age 14-19, must have new instruments and skills for reaction and self-realization in new dynamic and quickly changing world. Authors discovered experience, problems and innovative decisions of practical realized state experiment project "Development business education in Ukraine as part of entrepreneurial state policy", which had started from six secondary's schools in Kropyvnytskyi (Central Ukraine). Project team used business-simulation ViAL+ for experiment and modernization of entrepreneurial education. Because, this instrument is adopted for Ukrainian conditions, laws and economic culture, traditions. This project became part of the developing of entrepreneurial skills of pupils, which is one of the priorities of the concept of the New Ukrainian School. Also, this experience became a case of providing of entrepreneurial education at the other Ukrainian regions. The main parts of experiment are courses for secondary school "Business Education" for 7-10 classes, summer schools of Business Leadership, local and All-Ukrainian business-tournaments. Also authors described experience of using simulation for youth 16-19 ages in colleges and universities. In articles also are revealed main problems and ways of solving.

1 INTRODUCTION

In modern conditions of transformation in Ukraine there was a need to reform the management of schools. The adoption of the Law of Ukraine "On Education" in 2017 launched mechanisms for structural reform of the management system and methods of carrying out the activities of schools. The Law stipulates that "the state guarantees the academic, organizational, financial and personnel autonomy of schools. The scope of autonomy of schools is determined by the Law, special laws and constituent documents of the school" (Verkhovna Rada of Ukraine, 2017). We need special trainings programs for semi-directors and directors of schools, colleges and universities. Also there are introduced business instruments into everyday and strategic activity of educational organisations. During the trainings we conducted research in the format of a survey on three questions: 1) who is the client; 2) which is a product of the educational institution; 3) which is a raw material. And also we identified the main areas of training of principals of school using business-simulation.

At the article we described:

- peculiarity of new conditions for economic and managerial training of principals;
- mental and professional features of perception of business education;
- modern instruments of forming of economic and managerial competencies during training of principals of schools.

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2 NEW CONDITIONS FOR ECONOMIC AND MANAGERIAL TRAINING OF PRINCIPALS

Based on this, schools of all levels become full-fledged business entities with different forms of ownership and in different statuses (budgetary institution, non-profit school, profitable school). And the main type of their activity is educational (Verkhovna Rada of Ukraine, 2017). In this regard, the introduction of economic and management approaches in the activities of schools becomes extremely important.

A sharp change in the role of the head of the school, the need to make a wide range of management decisions make not only to the established pedagogical norms of the school, but also to the traditional tools of business management. Given that the educational and business spheres of operation are quite distant and little intersect, one of the tasks of economists and scientists-educators is to approximate, adapt and implement economic tools of management and analysis in the daily activities of the school.

It is worth recalling the basic legislative changes that operate in the light of the current Law of Ukraine "On Education" in accordance with the levels of education Analyzing the legislative changes in the Laws of Ukraine "On Professional Higher Education" (Verkhovna Rada of Ukraine, 2019, 1998), "On Complete General Secondary Education" (Verkhovna Rada of Ukraine, 2020)t is worth noting the following innovations:

- independence in certain forms of education, forms of organization of the educational process;
- the right to form and approve one's own staff list, respectively, free employment and dismissal of pedagogical, scientific-pedagogical and other employees;
- independence in financial, economic and other activities in accordance with the legislation and constituent documents;
- free disposal of own revenues;
- the head of the school directly manages the activities of his institution, he is a representative in external relations with state bodies, local governments, legal entities and individuals;
- the head decides the financial and economic activities of the school, forms its structure, forms and approves the staff list in accordance with the law, is the manager of property and funds, ensures compliance with staff and financial discipline;
- the head ensures the development and is responsible for the implementation of the approved development strategy of the school;
- the head is responsible for the results of the institution of professional higher education before the founder (founders) or his authorized body (persons) (Verkhovna Rada of Ukraine, 2019, 2020).

A balancing role in the system of strategic management of an school is played by the pedagogical council of the school:

- determination of strategy and perspective directions of development of school;
- considers the draft constituent document of the school, as well as proposals for amendments to it;
- considers the draft estimate (financial plan) of the institution and the annual financial report of the school, and other significant strategic steps (Verkhovna Rada of Ukraine, 2020).

Analyzing such changes in the adopted profile laws, which correspond to the Law of Ukraine "On Education", we can predict that in the new version of the law on vocational (technical) education in terms of powers of the institution, its head and collegial body will be written similar provisions. These steps lead to one thing – the need for radical change in the training and retraining of managers in the education system.

The offered article considers ways and ways of economic, administrative preparation of heads of schools and their deputies in the conditions of reforming of education.

3 MENTAL AND PROFESSIONAL FEATURES OF PERCEPTION OF BUSINESS EDUCATION

In Ukraine during 2016-2021, research and experimental work of the all-Ukrainian level on the topic: "Development of business education in Ukraine as an element of state policy to promote entrepreneurship", approved by the Order of the Ministry of Education and Science of Ukraine No. 1221 from 07.10.2016, was proposed and conducted a training course for directors and semi-directors of preschool, secondary, vocational and higher education on the topic: "Implementation of economic approaches in the management of schools". During 2017–2019, 1225 training participants from all regions of Ukraine were covered (table 1). We chose the regions based on the openness of the regions themselves, readiness for change and training of their principals.

Table 1: Statistics of participants of trainings.

Region	2016-2017	2018-2019
Vinnitsa	0	41
Donetsk	0	36
Zakarpattia	120	60
Kyiv	72	383
Kirovohrad	15	66
Luhansk	0	41
Lviv	50	138
Sumy	0	45
Ternopil	28	50
Kherson	3	0
Cherkasy	0	4
Chernivtsi	30	37
Total	80	238

During the training, participants were interviewed on the following similar issues:

- Is the school an economic entity?
- Who is the client (s) of the school?
- What are the products (services) of an school (main and secondary)?
- What is the "raw material" of an school? What other resources are needed?

The results of the survey show a number of trends in education:

- for more than 50%, directors were agreed that schools are part of economic systems;
- for 87% of participants the pupil / student is the raw material of the schools;
- the products of the school are graduates, competencies, certificates / diplomas;
- clients of the school are parents, the state, universities, sometimes businesses, public organizations;
- for some directors there is a rejection of the introduction of the principles of classical management in the management of schools and the need to understand economic issues.

These answers reflect the gap in the perception of the customer, product, input resources between schools and representatives of private business, in particular training and education centers, which clearly understand these positions. There are objective and subjective reasons for this situation.

Objective reasons:

- the legacy of the industrial economy – all had to be adjusted to the production system. Who did not fit or ruled, or "fell out" of the system of economic relations;
- absolutization of the state in the socialist system;
- low human value in the USSR.

Subjective reasons:

- unwillingness to change quickly and understand all the laws of a market economy;
- lack of tools for adaptation from systemic, public administration to autonomy and self-government;
- legislative "leapfrog" with changes and the possibility of rolling back reforms;
- non-acceptance of each other's educational and business community, different "languages", principles and approaches to solving issues.

These reasons are significant obstacles to the training of heads of schools in economic and managerial approaches. And in order to train managers and effectively retrain it is necessary to take into account the peculiarities of the implementation of the economic style of management of the organization.

The first economic management should be a system that covers all levels of operation: customers (pupils / students), teachers / lecturers, deputy principals and principals (figure 1).

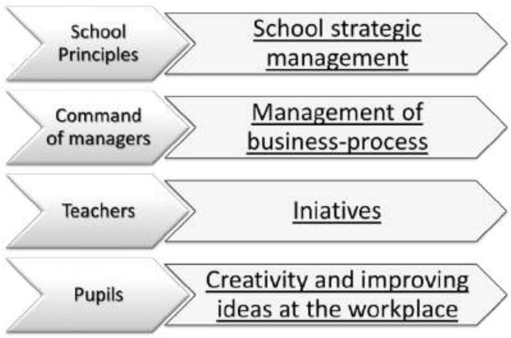

Figure 1: Development of entrepreneurial in education.

At each level it is necessary to implement the approaches and methods. For leaders, it is recommended, first of all, to look at the entrusted school not from the point of view of a teacher, organizer, pedagogical manager, but from the point of view of an economic non-profit organization. Such an organization has many business processes, and which should function as efficiently as possible and use the allocated public funds from the state and / or local budgets.

This will help to develop economic thinking, which is based on a simple but vital position: any result should always be greater than the spent material, financial, informational, time resources. If such equality is not ensured, then such a solution should be revoked or implemented so as to reduce the cost of limited resources.

At the level of deputies, the range of responsibilities is radically expanding. Today it is not enough to be responsible and manage only educational activities. It is necessary to move to a full range of management in various areas:

- marketing of the school (information, image policy, admission campaign);
- financial (ensuring such a state that funds are always enough for all costs in full and at the right time);
- HR-management (to form an initiative and self-supporting team, which prevents moments of emotional burnout and recession).

Only in this case can we talk about the introduction of real autonomy and full management of the entire educational system.

However, building an effective internal governance mechanism is not yet possible guarantees the successful operation of the school as a whole. After all, any school significantly depends on the external environment and the influence of all stakeholder groups. The main such groups are other schools of different levels (both relevant and related), clients (students, parents), business as sponsors and as future employers for educational services, with the founders and authorities in the field of education.

Heads of schools take care of external communication. Because strong interaction and balance of educational programs must be built between different levels of education, so as to ensure a progressive and continuous learning process. After all, youth who enters the formal education system at 2 years and leaves it at 19-25 years, must clearly understand where and how to move in adult life, must be able to earn their skills, knowledge, be professional and acquire basic competencies (competencies in understanding of business).

This approach means that there can be no "gaps" in approaches, forms of learning at the intersection of educational levels. For example: the last year of kindergarten corresponds to the 1st grade of school, 9th grade – with the 1st year of college. Graduation from the 11th grade of the school opens opportunities for study in the first year of universities and high colleges.

Today, as in previous years, there is a big discrepancy between the last classes of school and the first months of study in university. Lecturers spend significant resources on adapting first-course students instead of effectively teaching them specialized disciplines and developing professional skills.

A similar situation arises between the 9th grade and the 1st year of VET. With the difference that the vocational education system often works to restore the student's motivation and try to direct him to adult life — because he did not fit into the "classical schemes" of schooling.

In interaction with the market of educational services, two key issues should be in focus. First, understanding what exactly the applicant for educational services, his parents, wants. Secondly, a clear answer to what exactly the community should allocate funds from the public budget intended to finance the school.

Regarding the first, the content of educational programs cannot be the same from year to year. On the contrary, it should be flexible, relevant to today's demands of young people. And the teachers themselves must also be modern, in demand in their subjects.

Regarding the second position, the value of educational services for the client, community (urban, rural, district, regional or national), an explanation of why budget funds are spent and what areas of training they should be allocated to benefit from it should be constantly confirmed communities.

It is worth working with business as equal partners. Elevation in the status of the head of a school opens opportunities for greater maneuverability in interaction with business, as both parties are free to make their decisions in search of mutually beneficial proposals. For business, first of all, schools are interesting from the point of view of the employer and the ability to quickly find employees. This is an interaction in the dimension of the labor market. And, if the school can fully satisfy the requests for training, the support from the business is provided.

If not, the dialogue will not take place. It will be easier and even cheaper for a business to train a specialist than to retrain someone. The possibility of such an alternative should be constantly considered by the head of the school.

Another source of interaction with business is the provision of mediation services in the search for employees (the provision of employment services in the context of the labor market). Education organizations have practically ready and motivated employees. And there is an opportunity to test and find the right employee.

As for the state, it is essential to ensure "transparent" rules of the game (regulatory system), which will determine the working mechanisms for all participants in the educational process and stakeholders. Therefore, there is a need for internal and external security. This is especially important for Ukraine.

This understanding of the prerequisites for building the internal and external economic environment of the school contributes to the successful learning and further restructuring of the school on the basis of organizational, financial, personnel, academic autonomy.

4 MODERN INSTRUMENTS OF FORMING OF ECONOMIC AND MANAGERIAL COMPETENCIES DURING TRAINING OF PRINCIPALS OF SCHOOLS

Economic and managerial (managerial) training of heads of schools pursues the main goal – to teach / improve the ability to generate ideas and implement them independently in the practice of autonomous and self-sufficient management of schools. And such training should take place not only by standard tools (lectures, seminars, trainings), but also by innovative methods with the involvement of game and simulation technologies. Because rapid, effective retraining of economic principles of managers, formed in a rigid hierarchy of public administration, is possible only by radical methods that directly affect thinking, behavior and form applied skills.

Among such technologies of innovative, fast and radical practical training of managers are:

- games;
- simulators;
- gamefication;
- virtual reality.

Each technology is suitable for use in certain conditions in the presence / absence of technical support. Comparative characteristics of each of the technologies are:

- Games – need scenario, need rules, participants and trainers, less interest after 3-5 rounds of playing, we remember that it is only game (Tokarieva et al., 2019). Minimum technical support.
- Simulations – learning by doing, need computer classes, not necessarily of trainers/moderators, reproduction of conditions of the real environment / object / process. Normal technical support.
- Gamification – using of game practices and mechanisms in a non-game context in real life, technical, organizational and high-level need of resources, involvement of natural human instincts: competition, achievements, status, self-expression, altruism, problem solving, formation of skills in the process of training and real life or in a specially created environment (Fedorenko et al., 2021). Need medium technical support.
- Virtual Reality – full immersion in a specially created environment, need special IT support and equipment, the participant virtually "lives" in such an environment, difficult exit from the environment. Must very high technical support.

When comparing different methods, the most appropriate to use are games and simulators, which are relatively easy to obtain, organize and conduct with minimal or sufficient (available to most users) technical conditions. As for gamification and virtual reality, today these tools are either not yet perfect, or are valuable in organization and use. And the use of such technologies requires considerable time and inclusion, which, as a matter of fact, does not have the heads of schools.

The use of game technologies, in particular, business games, in professional development of managers is sufficiently described in the pedagogical literature. But the issue of using simulators, in particular business simulators, is not covered enough, and is often unusual and new for the pedagogical management community (Antoniuk et al., 2021).

Simulation technologies are interactive systems that reproduce the conditions of a particular environment, object, process using mathematical models. Examples of simulators are flight simulators, automobiles, locomotives, meteorological, physical, etc. Economics and business often use business simulators, which are interactive models of the real business environment in the form of a computer program that reproduces a structural unit of the company, an entire firm, industry or the economy of the whole country (Banshchykov and Pazdrii, 2017).

The history of creation and use of simulators is more than 50 years and has its roots in the military sphere. The leaders are Great Britain, the United States, Japan, Germany, and Scandinavian countries. In some countries, simulators are used at all levels of education – from preschool to adult education. Because this technology allows you to acquire practical skills and abilities.

A business simulation is a computer program, a large-scale interactive simulation system that is specifically designed to provide participants with economic and managerial competencies and skills. The main simulators are to create opportunities for the acquisition of practical skills in managing the economic processes of the entire technological chain of production, marketing and competition in the market environment, as well as the management of the enterprise as a whole. Today in the world there are hundreds of professional simulators with varying degrees of immersion and elaboration of processes. Ukraine also has its own products that are actively used in educational activities (figure 2).

The effectiveness of gaining practical skills while participating in interactive business simulators is en-

Figure 2: Well-known business simulations in the world and Ukraine.

sured by the application of the method of learning by doing (learning by doing), which gives the participant the opportunity to:

- not only observe the processes of functions of the enterprise, but also to make specific economic and managerial decisions that have real and adequate consequences for further activities;
- to acquire and improve theoretical knowledge of economics and management, to understand the causal links in the management of economic processes;
- simulators try to realistically reproduce the processes of functioning of the production enterprise, starting with the organization of production and ending with the sale of manufactured goods in conditions where there are different types of market – from duopoly to monopolistic competition.

After registration in the system, the participant receives an enterprise in an environment close to reality and has the opportunity to make economic and managerial decisions necessary for the start of its work and further development. The participant is given the opportunity to use existing financial instruments in Ukraine, to determine the range of products planned for production, to master it in production, to expand and modernize the production technological base, to hire and organize the work of personnel. Using appropriate marketing tools, the participant has the opportunity to start promoting and selling products.

In addition, it should be emphasized that the company is in a market environment, and when making decisions it is necessary to take into account the presence of other market participants. Thus, competition in the virtual market space forces the participant not only to look for effective tools and ways to promote the product, but also to make changes in the production process in order to change the consumer qualities of products and optimize its cost (Pazdrii et al., 2019).

For teachers and management of schools, participation in business simulators is quite difficult, as it is necessary to master economic terminology, methods and approaches to decision-making in a market environment, analysis of decisions and results.

During 2015-2020, 120 trainings were held and as part of the annual business tournament “Company Strategy” a league of mentors was opened using the ViAL+ business simulator. About 600 leaders, deputies, teachers became participants. During this ViAL+ business simulation, the participant goes through several stages:

1) there is an adaptation to the simulation environment (5-6 periods);
2) a comprehensive vision of the company is formed as a system, which, at the same time, consists of interconnected functional units (10–12 periods);
3) the understanding of causal relations of management of economic processes of the enterprise in the competitive market environment (18–20 periods) is formed;
4) after that – conscious implementation and adjustment of the previously formed action plan, professional analysis of the results (after the 20th period);
5) consolidation of acquired competencies and practical skills occurs after 25 periods.

The usefulness and need for such trainings was noted, but there is also a significant entry threshold. In this regard, it is worth noting the necessary prerequisites for the use of business simulators in the retraining of managers and training of future managers:

- clear arrangement of tasks and setting to go beyond traditional learning and existing patterns;
- preparation of participants for economic terminology, logic of management decisions in market conditions;
- updating of digital skills of training participants;
- assistance with the first decisions, a full explanation of the consequences of decisions and what to look for;
- constantly explain the relationship between business processes and processes in schools in the light of the implemented reform of the education sector.

During 2018–2020, 230 managers, deputy heads of secondary, vocational, higher education institutions or their structural subdivisions were trained using simulators. For 67% there was a significant and quite significant increase in ownership of economic and managerial competencies.

5 CONCLUSIONS

Complex and systematic use of various innovative pedagogical technologies in the process of professional development of vocational school leaders makes it possible to rationally use teaching time, motivate students to self-development and self-improvement, while increasing the level of psychological, methodological, didactic and managerial competence.

The technology of professional development of heads of vocational schools has its own specifics, structure, stages. It is an effective tool for achieving professional self-improvement, acme peaks, competencies on a spiritual-axeological basis, initiation of rethinking, self-overcoming, self-determination, self-realization of a specialist, creative transformation of all professional activities based on conscious self-development.

The study does not cover all aspects of the problem. The subject of further scientific research may be the study of foreign experience of professional self-improvement of heads of vocational schools; development of effective pedagogical technologies aimed at improving personal and professional qualities, in particular through a set of psychological and pedagogical trainings and self-trainings.

To further improve the training, it is necessary to create a specialized simulation of schools in terms of economic and organizational autonomy. This project envisages the creation of an existing simulation, which will model the activities of the school and the competitive economic environment, the creation of a simulation by all participants. Such a simulation will be designed to prepare principals, deputy principals, teachers-methodologists to work in the new conditions of the school, in which funds will be allocated not to a particular school, but to students in the form of certificates. This will force schools to fight for the attraction of more able students, and, accordingly, will open space for competition between schools and create conditions for improving the quality of educational services for students.

Thus, modern changes in legislation and the reform of schools are forcing the search for innovative ways of training, education and retraining of managers in educational activities. Such tools include game and simulation technologies. Today, you should use leading business simulators. However, in the future we will hope for the implementation of a specialized simulation of schools.

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Training on Gender Mainstreaming in Project Management: Case of International Donor Programs and Projects for Ukrainian Local Communities' Development

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Keywords: Gender Mainstreaming in Programs and Projects, Gender Training, International Donor Projects, Local Development Projects, Project Management, Women in Project Management.

Abstract: In recent years, the concept of gender mainstreaming in project management has become more popular and in demand. Mainstreaming gender in project management cycle requires knowledge and skills of all stakeholders and coordinated actions and commitments of all actors (government, international donors, territorial communities, non-governmental organizations, educational institutions and others). The paper focuses on finding an answer to the main question – how to mainstream gender in project cycle management to ensure effectiveness and gender-sensitivity of local development projects, taking into account the requirements of international donor programs and projects. The paper highlights the main issues of theory and practice of gender mainstreaming in programs and projects, engendering of community-based development projects, role and participation of women in project management, prospects of implementing gender mainstreaming concept in educational process for project managers. Questions which are raised in paper are: "What is gender mainstreaming and how it should be implemented into project cycle?", "How to mainstream gender in different types of Ukrainian local-development projects according to requirements and approaches of international donors and national legislation?", "What is project management now and how it would change in the future?"; "What is the current state of women in project management profession – globally and in Ukraine?"; "What challenges / barriers / obstacles women face as project managers?"; "Prospects for women in project management – how can they meet challenges and overcome barriers?", "How gender mainstreaming should be implemented in the design of education policies and programs for project managers?".

1 INTRODUCTION

The importance of diversity in project management was emphasized by many researchers (Okoro, 2016; Australian Institute of Project Management, 2020; Hunt et al., 2015). Okoro (Okoro, 2016) considered prioritizing diverse talent as a key resource for enhancing project success, and one way to achieve it is to increase women's participation in project management (in numbers as well as in levels and scope of programs and projects). The Australian Institute of Project Management (AIPM) identified "diversity by default" as one of its core values but reported still low level of female members (22%) (Australian Institute of Project Management, 2020). McKinsey's research defined diversity from two perspectives (gender and ethnic/racial characteristics) and analyzed the relationship between the level of diversity in the leadership of large companies and companies' financial performance (Hunt et al., 2015). Authors found a

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statistically significant relationship (correlation) between them (Hunt et al., 2015).

Issues of women as project managers were studied from different aspects. Thus Bielińska and Osbert-Pociecha (Bielińska and Osbert-Pociecha, 2018) examined the benefits of increasing participation of women in project management as well as factors determining their effectiveness (case of Poland). Henderson et al. (Henderson et al., 2013) explored women project managers as a group in the present project context within which they work in order to identify their project challenges and perspectives in this profession. Duong and Skitmore (Duong and Skitmore, 2003) examined the extent to which workplace problems may cause low numbers of women project managers based on survey of the Australian Institute of Project Management members.

Other area of research focus is the women representation in the leadership of major projects (Pritchard and Miles, 2018). This report explored wider issues of social responsibility, organizational culture and gender equality in order to find answer why women continued to be underrepresented in leadership of major projects and what it could mean for the project management profession (Pritchard and Miles, 2018). Mascia (Mascia, 2015) examined whether women have advantages over men at transformational leadership (with greater emphasis on emotional intelligence and interpersonal skills) and if so what are the reasons of women underrepresentation in project leadership. The differences in gender managerial styles were studied in paper (Rodríguez et al., 2017).

Henderson and Stackman (Henderson and Stackman, 2010) explored gender differences in project managers related to gender differences in their team members (location to one another, use of technology, the cost and size of project teams). Gender equality issues of the project strategic management in R&D organizations (case of Serbia) were examined by Obradović et al. (Obradović et al., 1912).

Atkins-Hansen (Atkins-Hansen, 2001) examined women in project management through a "glass ceiling" concept (invisible barriers that prevent women from advancing movement-development) which can be analyzed from two perspective: 1) individual project manager (particular female) and 2) project management discipline. Maxwell (Maxwell, 2007) explored negative consequences of "glass ceiling" regarding women in non-traditional jobs (particularly female project managers) as well as the attitudes and perceptions that prevent women to reach their full potential as project managers.

Also authors examined articles from key journal "Gender in Management" (GIM) published over the period 2016–2020. GIM is the leading journal in the field with focus on empirical research, theoretical developments, practice and current issues within the context of gender, management and leadership particular the theme of female entrepreneurship and management.

The main focuses of researches over this period were corporate governance, analysis of differences between women and men (from different prospects) and conflict of interests. The topic of women' leadership particularly in male-dominated industries and gender diversity in top management were examined in a lot of articles. However the topic of women in project management received less attention. In this context worth mentioned article (Olofsdotter and Randevåg, 2016) which examined how masculinities are reproduced in project-based organizations (based on construction project managers case study) with practical recommendations of creating more equal work-environment in the construction industry for female and male managers.

However, the issue of the role and participation of women in project management is part of a broader direction of research and practice, namely the implementing of a gender approach (gender mainstreaming) in all spheres of life, including project management in order to achieve gender equality. Ramsak (Ramsak, 2017) studied the process of implementing gender mainstreaming in projects and programs emphasizing that different types of projects have different impact on gender norms and stereotypes. It is important to understand strategic entry points for integrate key gender dimensions into project cycle as well as monitor and evaluate project using gender indicators.

A significant amount of research is devoted to analysis of methods for mainstreaming gender equality particular in community-based development programs and projects and approaches and tools proposed by international donors (Arenas and Lentisco, 2011; Haataja et al., 2011; UNIDO, 2015). Thus one of the major points of implementing such projects is integrating gender into project cycle management as well as training project managers and teams responsible for design and development of effective and sustainable local development projects using tools, methodologies and principles with a gender perspective.

The main point of this paper is to find out answers on following questions:

1) is gender mainstreaming and how it should be implemented into project cycle;
2) to mainstream gender in different types of

Ukrainian local-development projects according to requirements and approaches of international donors and national legislation;

3) is project management now, how it would change in the future, and what is the current state and challenges of women in project management profession;
4) for women in project management – how to meet challenges and solve problems;
5) gender mainstreaming should be implemented in the design of education policies and programs for project managers.

2 GENDER MAINSTREAMING IN PROGRAMS AND PROJECTS: CONCEPT

Gender mainstreaming first came up as a concept in 1985 at the United Nations Third World Conference on Women in Nairobi. In 1995, the Platform for Action adopted at the Fourth World Conference on Women in Beijing explicitly called upon governments and other actors to promote gender mainstreaming. Gender mainstreaming is based on the recognition that:

1) men and women have different needs and living conditions, and that development policies can affect them differently;
2) women tend to have more limited access to and control over power, money, human rights, information, justice, resources, benefits and decision-making opportunities, and therefore more limited opportunities to participate;
3) projects should be designed in a way to ensure that men and women benefit from them equally and that neither group is inadvertently disadvantaged or ignored (Council of Europe and Directorate of Internal Oversight, 2015; Commonwealth secretariat, 2019).

Mainstreaming gender means ensuring equal opportunities and non-discrimination practices in all policy development and implementation. If gender is mainstreamed, all actions should be planned, implemented, monitored, reported on, and evaluated with a gender perspective in mind (Council of Europe and Directorate of Internal Oversight, 2015, p. 7).

Thus gender mainstreaming is a strategy that was formally included in the Beijing Platform for Action in 1995 and is most often defined by the 1997 United Nations Economic and Social Council (ECOSOC) interpretation of the term: "Mainstreaming a gender perspective is the process of assessing the implications for women and men of any planned action, including legislation, policies or programs, in any area and at all levels. It is a strategy for making women's as well as men's concerns and experiences an integral dimension in the design, implementation, monitoring and evaluation of policies and programs in all political, economic and societal spheres so that women and men benefit equally and inequality is not perpetuated. The ultimate goal is to achieve gender equality" (UNIDO, 2015, p. 4).

Gender mainstreaming includes creating and sharing knowledge, awareness and responsibility for gender equality. It is also a strategy for including the concerns of girls/women and boys/men in the design, implementation, monitoring and evaluation of education policies and programs so that girls and boys, women and men benefit equally (Frei and Leowinata, 2014, p. 8).

The Council of Europe defines the concept of gender mainstreaming as "the (re)organization, improvement, development and evaluation of policy processes, so that a gender equality perspective is incorporated in all policies at all levels and all stages, by the actors normally involved in policy-making" (Council of Europe and Directorate of Internal Oversight, 2015, p. 8).

Gender mainstreaming is a very effective tool for achieving gender equality. Gender mainstreaming means that gender equality issues are integrated into all activities. Gender mainstreaming is not a one-time activity, instead, it requires ongoing attention. The range of activities involved in gender mainstreaming includes:

- identifying gaps in gender equity;
- raising awareness about inequality;
- promoting and building support for change;
- providing resources and expertise to make needed changes,
- monitoring results and evaluating progress;
- providing information about the results of gender mainstreaming activities (Frei and Leowinata, 2014, p. 33).

Taking the gender perspective into account means that the objectives and contents of activities can be developed to better meet the different needs of various groups. It therefore represents one way of improving the quality and impact of activities.

Gender mainstreaming is necessary for several reasons:

1) identify gender differences and inequality;
2) make the case for taking gender issues seriously;
3) design policies and plans that meet women's and men's needs;
4) monitor the differential impact of policy, project and budget commitments on women and men (Frei and Leowinata, 2014, p. 35).

The aim of gender mainstreaming is to change gender neutral (taking no account of gender) ways of thinking and procedures, and the related operating culture (Haataja et al., 2011). The ultimate goal of gender mainstreaming is advancing gender equality; it's not mainly about increasing women's participation, it "facilitates equal opportunities, benefits and outcomes for girls/women and boys/men" (Frei and Leowinata, 2014, p. 6).

Key steps to process of gender mainstreaming:

1) conduct a gender analysis (collect sex-disaggregated data and analyze these data by using a "gender analysis": Who is valued? Who makes the decisions? Who has a say over resources? Who is rewarded? Who has the power to act? Who is overlooked? What strategic and practical needs are being addressed or overlooked?);
2) involve women and men in creating the agenda (identify the obvious, less obvious and least obvious gender equality issues and gaps through an analysis of the data and through consultations with both women and men to make an appropriate diagnosis of the problems);
3) develop actions that fit the context and design projects that address these issues (What kind of change is required: legal, policy, cultural, services, personal, political?);
4) build capacity for change (Commonwealth secretariat, 2019; Frei and Leowinata, 2014).

Progress of gender mainstreaming implementation was introduced as a concept of gender mainstreaming ladder (table 1) (Frei and Leowinata, 2014, p. 37).

Factors influencing the level of gender mainstreaming (based on the research results on gender mainstreaming in cooperation programs and projects):

1) the internal triggers and reasons for gender mainstreaming:
   – staff members are more likely to mainstream gender if they consider it relevant for their work and/or have undergone some gender training (staff members who are interested in the subject matter are more likely to perceive gender mainstreaming as relevant for their work than those who are not);
   – peers and senior management are more of a supporting factor than any entities and structures whose mandate it is to promote gender equality or to coordinate cooperation; item[−] the most important internal obstacle to gender mainstreaming in cooperation relates to a lack of gender mainstreaming training and gender analysis tools available for staff;
2) the external triggers and reasons for gender mainstreaming:
   – the influence of the donor was a very significant factor for introducing the issue of gender into programming (especially the Canadian International Development Agency, the Scandinavian countries and Switzerland insist on the incorporation of gender issues);
   – the interest of cooperation partners in the issue:
   (a) sometimes governments specifically request gender mainstreaming since they have identified the issue of gender equality as a priority area: as a result of their own analysis or specific requests from international institutions such as the European Union (EU), which make improvements in gender equality a precondition to providing (continued) support;
   (b) a high level of awareness on the part of the civil society – local and international non-governmental organizations (NGOs) (Council of Europe and Directorate of Internal Oversight, 2015).

EU introduced dual strategy for promoting gender equality which entails that the gender perspective must be included in all planning, activities, decision-making and assessment on program and project level, in addition to separate gender equality program and projects being implemented from time to time to achieve more marked leaps in development (Haataja et al., 2011).

Therefore government and international development actors often use a combination of two strategies in order to promote gender equality:

1) gender equality intervention (specific intervention with the primary aim of promoting gender equality);
2) gender mainstreamed intervention (intervention which mainly aims at objectives other than gender equality but which promotes gender equality in addition to these other objectives, meaning that

Table 1: Gender mainstreaming ladder.

Stage	Content
Stage 6 Learning and action mainstreaming	Gender equality changes have clearly been acted on, systems for monitoring and evaluating results are set up, further gender analysis is done based on the new data, and more changes are introduced as needed.
Stage 5: Implemented mainstreaming	It is clear how the institutions and teachers acted on the gender-equality changes recommended by the gender analysis, and integrated them into the curricula.
Stage 4: Institutionalized mainstreaming	The results of the gender analysis are evident in some aspects of how the institutions or teachers acted on the findings, including by changing the curricula
Stage 3: Integrated mainstreaming	A gender analysis is done, but there is little evidence of how the institutions or teachers consistently acted on the findings or made changes to the curricula.
Stage 2: Pro forma mainstreaming	A token sentence or paragraph is found in institutional or curriculum design documents, with no evidence that it affected the structures, how teachers are trained or how classes are taught.
Stage 1: Zero mainstreaming	There is no mention of gender equality anywhere, or just an obviously superficial reference.

everything they do also promotes gender equality) (Council of Europe and Directorate of Internal Oversight, 2015).

In this paper authors are concentrated on the second type of strategy – gender mainstreamed intervention.

Mainstreaming gender in projects aims to avoid the creation or reinforcement of inequalities, which can have adverse effects on both women and men. It also implies analyzing the existing situation, with the purpose of identifying inequalities, and developing policies which aim to redress these inequalities and undo the mechanisms that caused them (Stella et al., 2017).

The European Institute for Gender Equality suggests that gender be mainstreamed throughout the project lifecycle and proposes seven tools and methods of incorporating gender in project planning and management:

1) gender analysis;
2) gender audit;
3) gender awareness-raising;
4) gender budgeting;
5) gender equality training;
6) gender evaluation;
7) gender impact assessment (Stella et al., 2017).

Five questions to promote gender equality in project planning:

1) data: have we counted all women and men;
2) analysis: do women/girls and men/boys have a fair share;
3) participatory engagement and accountability: have both women and men been consulted;
4) policy, action, resources: have we invested equally in women and men;
5) individual, organizational, social change: decision makers and project team have the skills, knowledge and commitment to make a lasting change (Commonwealth secretariat, 2019).

3 INTERNATIONAL DONOR PROGRAMS AND PROJECTS FOR LOCAL DEVELOPMENT TO SUPPORT COMMUNITIES IN UKRAINE

The current approach to mainstreaming gender equality in development cooperation is the result of a gradual process of reflection in the international community, in both academic and development circles (Haataja et al., 2011).

The World Bank defines community-driven development (CDD) as programs which "operate on the principles of local empowerment, participatory governance, demand-responsiveness, administrative autonomy, greater downward accountability, and enhanced local capacity" (Browne, 2014, p. 1).

CDD is strongly supported by the World Bank and much of the literature comes from the World Bank's reports and publications. There is a reasonable amount of evidence and rigorous research conducted on gender outcomes, although this could be strengthened.

Key lessons from the literature are:

1) elite capture is a significant concern ("uncontrolled" CDD will not necessarily benefit women, the poor and other disadvantaged groups);
2) women's participation is a central problem (they do not usually have the time and/or confidence to contribute to community planning processes);
3) to reach women and other disadvantaged groups, CDD needs to have explicit targets for them or mandatory participation requirements (programs with an explicit gender strategy are more likely to impact on women's empowerment than programs without clear gender equality goals);
4) programs which allow women-only space appear effective in enabling women's voice and developing projects that respond to women's needs;
5) CDD programs struggle to change attitudes and norms around women's social position (they are often successful at engaging women in projects, but fail to make significant changes in the long-term);
6) examples of positive gender outcomes are improved women's participation in village-level meetings and processes; personal empowerment and voice; women's access to services; increased skills and independent income (Browne, 2014).

The challenge of elite capture has prompted donor control of targeting and active gender-equality policies.

Strategies to overcome obstacles:

1) implementing partners with an explicit gender inclusion strategy were more successful at achieving high rates of women's participation in decision-making than partners without a clear strategy;
2) quotas are a commonly used tool to overcome the challenge of women's participation;
3) implement women-only groups to discuss, propose and manage CDD projects;
4) NGOs have tackled the obstacles to women's participation by attempting to free up their time and by capacity building.

CDD programs should have a gender balance in their own staff, particularly with enough female facilitators to engage effectively with female beneficiaries.

The local elections on October 25, 2020 end the second phase of decentralization in Ukraine. The success of decentralization largely depends on the coordinated work of all participants in the process – the government, parliament, associations of local self-government (LSG), the donor community, experts.

The main advantages of decentralization and the reform of local self-government implemented on its basis from the point of view of LSG include the following:

1) ensuring the strategic freedom of participants in the management process in territorial communities;
2) formation of bases of self-organization and generation of incentives for active activity in communities;
3) creating a balance of real LSG independence (freedom of choice in decision-making – responsibility for their results);
4) stimulating interest in the appropriate end results;
5) the growing role of leaders and the formation of incentives for their personal development (Bezugliy, 2017).

The Ministry for Communities and Territories Development of Ukraine (MinRegion) is the main body in the system of central executive bodies that ensures the formation and implementation of state policy in the field of local self-government development, territorial organization of government and administrative-territorial organization.

Ukraine has established a Donors' Council, which brings together all programs and projects provided by international donor organizations to support decentralization processes in Ukraine (Ministry of Regional Development, Construction and Municipal Services of Ukraine Implementation of Decentralization in Ukraine).

In order to reap the benefits and meet the challenges, achieve the set goals and achieve the planned result, the project approach to management is gradually introduced in the local communities and the tools and methods of project management are applied. This trend of increasing the role of the project approach in local socio-economic development in Ukraine is in line with European trends, where projects are a means of achieving priority goals in regional strategic planning (Bezugliy, 2017).

For the united local communities (ULCs, gromadas), projects are now becoming the main means of implementing change. Thus, within the framework of the state financial support for the development of ULCs, subvention funds from the state budget were provided to the gromadas' local budgets for the implementation of infrastructure projects. The Resolution of the Cabinet of Ministers of Ukraine of March 16, 2016 No. 200 approved the "Procedure and conditions for granting a subvention from the state budget to local budgets to support the development of united local communities, which stipulates that the subvention is provided for implementation of projects property" (Cabinet of Ministers of Ukraine, 2016).

Also, gromadas have the opportunity to submit project applications for the implementation of investment projects and regional development programs for funding from the State Regional Development Fund (SRDF), which is created within the state budget and allows to start financing regional development projects in Ukraine on a competitive basis and accordingly to regional development strategies.

The study of the peculiarities of the project approach application in local self-government, which was conducted during 2014–2016 through online surveys of 273 representatives of local communities, revealed a number of problems, namely:

1) focus on short-term and small-budget projects on traditional topics (often implemented large-budget and medium-budget projects only 12% and 17% of respondents, respectively);
2) low readiness (and ability) to conduct a thorough project analysis (project analysis is carried out by 50% of respondents);
3) absence in the communities of specialists trained for project activities (27% of respondents) as well as project activities regulations and reglaments (almost 50% of respondents);
4) the communities need for external methodological support for the use of project management tools and the high-quality projects development (more than 90% of respondents) (Bezugliy, 2017, pp. 155–156).

Currently, the creation of ULCs is accompanied by an increase in demand for the introduction of a project approach in community activities and the use of tools and methods of project management for planning and achieving local development (Bezugliy, 2017).

There are the following main areas of project approach application in ULCs:

1) formation of state (regional) target programs;
2) implementation of priorities identified by ULCs' development strategies;
3) solving certain problems of local development.

In this context, local development projects are defined as: an instrument of systemic change management; the main tool of implementing strategic goals / priorities and achieving the mission; "a leading tool for the programmed achievement of community development goals" (Bezugliy, 2017, p. 34).

Local self-government projects are defined as "projects of strategic development of local communities, which are implemented at the request of the local self-government body and implemented with the involvement of state and non-state sources of funding and participating organizations" (Bezugliy, 2017, p. 58).

Specifics of local self-government projects: usually complex multifaceted sets of works, pursue a wide range of goals, are performed with the involvement of different categories of participants and are associated with obtaining various benefits for the local community (Bezugliy, 2017).

Researchers distinguish 2 groups of local development projects:

1) investment projects (create material objects, require capital investments for their financing, for obtaining which in most cases investment attraction special mechanisms are required);
2) social projects (create, mainly, intangible objects or other public goods; do not require capital investment and can be implemented through current funding, or various grants that do not involve capital expenditures) (Bezugliy, 2017).

Over the last two decades, decentralization and support for the development of local self-government have become the main areas of international cooperation.

In Ukraine, one of the possible sources of funding for local development projects is grants from international donor organizations and foundations (as the main source for funding individual projects and as co-financing of projects). The activities of international donor organizations require significant activity and a certain level of project skills development on the part of communities. However, in local communities, grant activities are underdeveloped and attracting grant funding raises many questions and often requires methodological external support for communities (Bezugliy, 2017).

According to the portal decentralization.gov.ua, within the framework of international cooperation to support decentralization and local self-government reform, 25 international donor organizations programs and projects are currently being implemented in Ukraine; the assistance amount is CHF 9,277 million; USD 55,0 million; EUR 154,81 million; SEK 41,71 million; CAD 19,489 million.

The largest (in terms of funding) five existing international programs and projects implemented in Ukraine to support local development:

1) program "Support to decentralization reform in Ukraine / U-LEAD with Europe: Program for Ukraine on local empowerment, accountability and development" (funding: EUR 152,3 million; implementation period: 01.01.2016–31.12.2023) (Official website and main information portal of local governance reform and territorial organization of power in Ukraine , decentralization);
2) the United Nations Recovery and Peacebuilding Pogramme (UN RPP) (funding: USD 80 million; implementation period: 01.11.2014–31.07.2022) (Official website and main information portal of local governance reform and territorial organization of power in Ukraine , decentralization);
3) the program "Decentralization brings better results and efficiency" (DOBRE) (amount of funding: USD 50 million; implementation period: 08.06.2016–07.06.2021) (Official website and main information portal of local governance reform and territorial organization of power in Ukraine , decentralization);
4) project "Partnership for urban development" (PLEDDG) – PROMIS Project (funding: CAD 19,5 million; implementation period: 27.03.2015–31.12.2020) (Official website and main information portal of local governance reform and territorial organization of power in Ukraine , decentralization);
5) "E-Governance for accountability and participation program" – EGAP program (funding: CHF 9,4 million; implementation period: 01.05.2015–30.06.2023) (Official website and main information portal of local governance reform and territorial organization of power in Ukraine , decentralization).

Main findings of gender mainstreaming in cooperation based on an overview of the extent to which gender has been mainstreamed in cooperation interventions between the Council of Europe and member states/neighborhood cooperation countries (mainly the period 2014 to 2017) and which could be taken into account for designing and implementing local development projects in Ukraine:

1) while about half of the survey respondents perceive gender to be mainstreamed in cooperation interventions, gender mainstreaming is only visible in very few logical frameworks and strategic documents that guide cooperation interventions (Council of Europe and Directorate of Internal Oversight, 2015, p. 12);
2) the different gender mainstreaming techniques have been applied to varying extents: techniques that require only a very small degree of familiarity with gender mainstreaming concepts (gender balanced participation in events) are used more frequently than more sophisticated measures (gender impact analysis and gender budgeting) (Council of Europe and Directorate of Internal Oversight, 2015, p. 21), figure 1 (Council of Europe and Directorate of Internal Oversight, 2015, p. 13).

In order to participate in international donor programs and projects and receive grant funding, communities need to build "project capacity" – to acquire the necessary knowledge, skills and experience in project management with gender mainstreaming perspective at all levels and stages.

4 THE ROLE AND PARTICIPATION OF WOMEN IN PROJECT MANAGEMENT: CURRENT STATE AND CHALLENGES

Project management is a relatively new area still developing as profession (Pritchard and Miles, 2018), however the last years world demand for project management is rapidly increasing (Bielińska and Osbert-Pociecha, 2018).

By the estimation of the World Bank more than 20% of global economic activity proceeds as projects (Pritchard and Miles, 2018). Projects differ in size, cost, scale: from small local or within-company projects to multi-national, multi-million-valued, development-critical, politically sensitive projects aiming to solve the most complex world challenges.

Many companies worldwide implement project management in their operations which leads to advancing project management towards higher levels, with more strategic focus and alignment with organizational goals (Atkins-Hansen, 2001).

Project Management Job Growth and Talent Gap 2017–2027 report (Project Management Institute, PMI) estimates that by 2027 87,7 million individuals working in project management-oriented roles will be needed across the globe (Anderson Economic Group,

Figure 1: Extent of use of gender mainstreaming techniques (on a scale of 1 – "never" to 5 – "always").

2017). Projectification studies that were conducted in particular countries or regions, including Germany (German Project Management Association, GPM), Norway and Iceland, suggest that the average national projectification level is around 33% of the country's GDP (Pritchard and Miles, 2018).

In this context the skills deficit is indicated to become a global issue to be addressed in all regions (skills gap) (Okoro, 2016) and project-based organizations are challenged by increasing skill shortages (Australian Institute of Project Management, 2020).

With growth of project management professionalisation issue of advanced paradigm becomes important (Pritchard and Miles, 2018). The high role in this process plays organizations like Project Management Institute and their charters in countries around the globe, International Project Management Association – IPMA, national project management organizations (Australian Institute of Project Management – AIPM, Chartered Institute of Personnel and Development – CIPD).

Important issue for achieving project success and overcoming this shortage of employees considers diversity (Okoro, 2016). Taking in consideration that project management has been a male-dominated profession and still remained despite a significant increase of "critical mass" of women (for many reasons which would be characterized later in paper) diversity means first of all increasing participation of women (Bielińska and Osbert-Pociecha, 2018). So diversity would define as a number of women participating in project management at all levels.

Managerial careers in general have traditionally been male oriented with women considering being less effective exerting authority (Duong and Skitmore, 2003). In addition to complex challenges for project management profession due to high uncertainty and ambiguity embedded in project environments women face the added challenges.

Current context of project management for women:

- the marginalization of women from the role of project manager (project manager is non-traditional job for women) (Maxwell, 2007);
- the lack of women in the leadership of major projects (women working in the profession of project management are not breaking into the significant role of project manager) (Pritchard and Miles, 2018).

The research results (based on the log-linear analysis of 211 female project managers in North America) show significant associations among women project managers' career, age, cost of their projects, and their professional certifications (Henderson et al., 2013). Demographics and characteristics that exemplify the project and team environments for women project managers:

- women 50+ years old are more likely to have a project management certification;
- women 50+ years old are more likely to have managed more costly projects;
- women with a project management certification are more likely to have managed larger projects;
- larger projects are more likely to cost more and have more geographically dispersed project members (Henderson et al., 2013).

Factors which explained the under-representation of women in the leadership of larger projects:

- most comes from STEM subjects and via particular "project-dense" sectors – engineering, construction, technology, defense, transport – that are still predominately male (from school to graduation and career choice);

- challenges of balancing an all-encompassing leadership role with other responsibilities (caregiving roles are still predominantly of women);
- "social judgment and ideals" of leadership (stereotypes and perceptions – old and new – of the roles men and women play at work and in society) (Pritchard and Miles, 2018).

Researches identified four advantages and four disadvantages for female project managers (table 2) (Henderson et al., 2013).

The interest in gender equality issue within the concept of project management is growing in the literature (Obradović et al., 1912). However in Ukraine this direction of research is at the beginning stage (there are no systematic studies on the role and participation of women in project management). Lack of data (not mentioned of its gender aggregation) on project management is one of the obstacle on this way.

In the context of project management professionalisation there are 2 bodies in Ukraine:

1) Ukrainian Project Management Association "UPMA"/"UKRNET" (UPMA, 2021);
2) Project Management Institute Ukraine Chapter "PMI Ukraine Chapter" (PMI Ukraine Chapter, 2021).

Ukrainian Project Management Association "UPMA" is a professional project management association in Ukraine which is "focused on promoting project, program and portfolio management using the competence development models of stakeholders with the possibility of their international certification" (UPMA, 2021). Since 1993 UPMA is a member of the International Project Management Association (IPMA). Since 1997 UPMA has a direct cooperation agreement with a Project Management Institute (PMI).

Among other types of professional activities UPMA conducts international certification of professional project managers, organizations, consultants and trainers (teachers) based on the IPMA system. UPMA's website (UPMA, 2021) provides information on project managers who have received certificates based on which gender data desegregation was made (table 3).

Only 27,8% women holds professional certificates granted from UPMA. Taking in consideration that women with a project management certification are more likely to have more opportunities for prominent careers this gender gap could be starting point for future researches.

The Project Management Institute Ukraine Chapter ("PMI Ukraine Chapter") is official representative of the international non-profit organization Project Management Institute (PMI). The top-management of "PMI Ukraine Chapter" (gender structure):

1) President – 1 (man);
2) Vice presidents – 7 (2 women; 5 men) (PMI Ukraine Chapter, 2021).

Only 2 women (25%) are on senior leadership position in organization. Such disproportion between men and women in project manager role is confirmed also by the gender structure of PMI association, where in 2008 30% of the members were women and 70% men.

Common barriers to women's advancement in profession (particular in project management):

1) the leaky pipeline (the problem of retaining women at every level of the organization);
2) maternity and caring (significant "funneling" of women before reaching senior leadership roles occurs around the ages of 28–40, and is particularly challenging for those returning from maternity leave);
3) recruitment (there are gendered barriers facing women seeking new employment opportunities);
4) leadership (the pressures of leadership roles mean that women aren't always seen as a desirable option, negative attitudes about the ability of women to lead);
5) gender pay gap (a difference in the pay of men and women – women typically earn less than men in comparable work);
6) sexist stereotypes (sexist behaviors and attitudes persist in organizations);
7) apathy towards diversity and gendered career choices (the push for gender balance masks the differences in representation between typically female-dominated and male-dominated professions) (Pritchard and Miles, 2018; Maxwell, 2007).

Women project managers' challenges could be divided on 2 groups:

1) general (the gender issues common for all types of women' professional development, reflection of historically masculine domination in societies):
   - traditional stereotypes towards women;
   - discrimination against women at the workplace;
   - difficulties of combining work and family;

Table 2: Women's self-described advantages and disadvantages working in the project management profession.

Type	**Characteristic**
Advantages	
Hurdlers	Strengths in communication, collaboration, and building professional relationships enabled them to overcome barriers in their roles as project managers.
Context setters	Context-sensitive and empathetic styles as project managers
Team managers	Being competent team managers (to bring diverse people together on project teams, and knowledge of how to create cohesiveness)
Presence	The unique manifestations of women project managers as themselves
—Disadvantages—	
"It is a man's world"	Men controlling power circles or inner circles from which women were excluded
Proving credibility	Credibility gaps between women and the men with whom they work
Stereotypes	Women were negatively stereotyped in some manner
Dismissed	Being pushed aside, discounted, and/or dismissed by males in their workplaces

Table 3: Certified project managers (based on the data from UPMA – Ukrainian project management association).

Type / level of certification	**Female project managers**	**Male project managers**
PPMC	1	2
PMC	2	4
Level A	10	25
Level B	18	51
Level C	17	50
Level D	7	23
Level E	18	24
P2M	31	91
Total	104	270
	27,8%	72,2%

- difficulties of accessing informal networks, and mentoring relationships;
- lack of support from male and female colleagues;
- low level of motivation, self-confidence, and career aspiration;

2) specific (the project culture additional challenges to women):
   - organizing under conflict, co-operative leadership, integrative thinking, ability to make quick decisions to adapt to the changing and group working dynamics;
   - different management styles and adopting male styles to survive in a masculine environment;
   - insufficient initial understanding of the project team cultures;
   - difficulty working with people onsite because of harassment and joking;
   - difficulties in applying particular project management techniques (Australian Institute of Project Management, 2020; Bielińska and Osbert-Pociecha, 2018; Duong and Skitmore, 2003).

Research findings regarding the job challenges that women project managers identify reveal six significant factors: visibility/risk, informal/persistence, formality, networks, newness, and diversity (Henderson et al., 2013).

A difference in the pay of men and women for comparable work in Ukraine is more than 20%. According to the State Statistics Service in Ukraine the ratio of average wages of women and men is ranged 75–79% (table 4) (State Statistics Service in Ukraine, 2020).

Table 4: A difference in the pay of men and women for comparable work in Ukraine.

	2015	**2016**	**2017**	**2018**	**2019**
Ratio, %	74,9	74,6	78,8	77,7	77,2
Pay gap, %	25,1	25,4	21,2	22,3	22,8

The target set for 2020 is 80% (decreasing gender pay gap to 20%).

AIN published a research by hh.ua on wages in the project management sector in Ukraine. Experts analyzed this sector by vacancies over the past 5 years in terms of gender desegregated data. The main results of the study (Yarovaia, 2020):

1) men top-managers significantly prevailed on women (70% of men's resumes and 30% of women's resumes, 2019);
2) gender differences in project management areas (men apply more: Production, Transport, Logistics, Finance; women apply more: Sales, Marketing, Advertising, PR, HR);
3) significant difference in expected income from men and women (table 5).

Table 5: Expected income applying on project manager position.

Salary range, UAH	Women, %	Men, %
Up to 24 400	29	23
Up to 48 800	56	38
Up to 73 200	5	19
Up to 97 700	5	9
Up to 122 100	5	5
More than 122 200	0	6
Total	100	100

These challenges result in the lack of career progress, inappropriate job assignment and training opportunities available for women; reduces the number of high profile projects and assignments offered to women; leads to the scarcity of females in decision-making positions.

Even in industries where the majority are women as, for example, in cultural management in Ukraine, women' role is usually less visible and valuable comparing to men. Often, even on similar roles and positions (as project managers), women in practice do more. Among the recommendations to change this situation should be mentioned following: promoting of women's self-realization models through educational initiatives and/or in the media, implementation of best practices and increasing women representation.

5 HOW TO IMPLEMENT GENDER MAINSTREAMING IN PROJECT USING PROJECT MANAGEMENT INSTRUMENTS

Gender mainstreaming is the main instrument implemented in all interventions with specific actions addressing gender gaps, inequalities and discrimination and anchoring gender in the organization. Project Cycle Management (PCM) is a standard tool, relied on around the developing world, consisting of interconnected steps for managing programs or projects in a systematic, holistic, result-oriented and accountable manner.

Gender mainstreaming is not an isolated exercise, but an integral part of the project or policy cycle. It is not an "add on" to project work but rather a technique to employ in all planning to ensure projects are even more efficient and effective. Practical gender mainstreaming is about running through a checklist of questions to ensure you have not overlooked anything or anyone. Thus it is about asking the right questions (Commonwealth secretariat, 2019).

Many development programs are implemented following a cyclical model, both at program and project level. A cyclical model divides the program development entity into five stages. Integrating gender strengthens the existing planning approach and methodology. It consists in engendering all steps and processes of PCM. At different cycle steps questions are asked to ensure that the processes and results integrate gender needs.

On program level, gender mainstreaming involves the inclusion of this perspective in the various stages of the program cycle depending of development project types in regards to degree of gender equality promotion. Therefore it is important to identify and acknowledge the significance of gender at all stages of the cycle (Haataja et al., 2011).

At project level, the gender perspective may be accounted for in two ways:

1) plan and implement a "gender equality project";
2) plan and implement a development project, in which gender is mainstreamed in the way required by the program, and to the required extent. It is important to identify the significance of gender equality in all projects not only to gender equality projects (Haataja et al., 2011).

Gender mainstreaming the project cycle serves to ensure that the intervention advances women's equal participation as decision makers in shaping the sustainable development of their societies and reduces gender inequalities in access to and control over the resources and benefits of development. These objectives are based on two principles:

1) women and men have different needs, roles, interests and access to resources and their benefits in local communities;
2) women and men have to play equally important roles in achieving inclusive and sustainable local development (UNIDO, 2015).

Overall, projects can be classified into four categories:

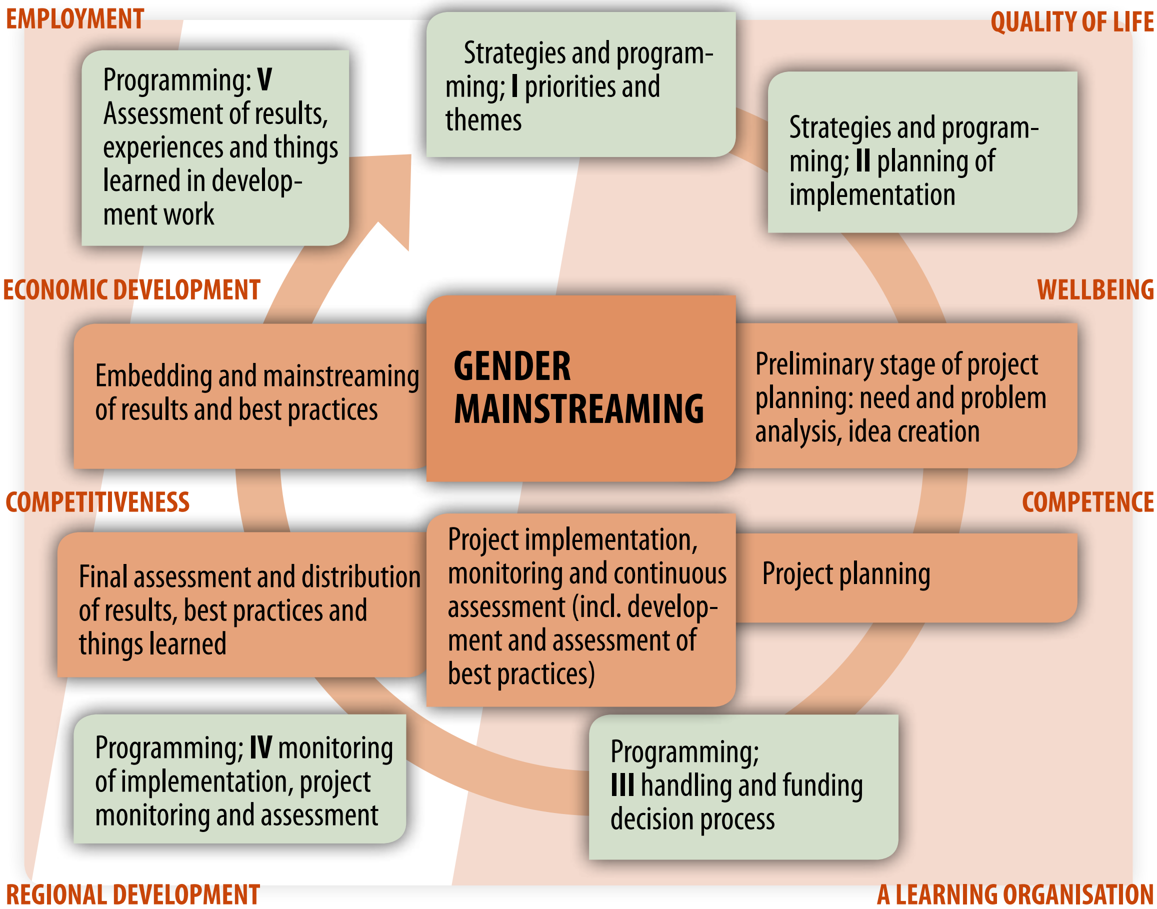

Figure 2: Gender mainstreaming in project work and programming.

1) gender-targeted projects;
2) projects with significant gender dimensions;
3) projects with limited gender dimensions;
4) projects with minimal gender dimensions (UNIDO, 2015).

A checklist for project planners on gender mainstreaming in projects:

1) clarify for yourself what gender mainstreaming entails at all stages of the project;
2) gain additional knowledge, training or guidance in gender mainstreaming for the project you are planning, if you feel that you cannot do all of this by yourself;
3) find out about gender equality and the gender perspective regarding the operating target of your project. This will provide a factual basis for planning;
4) on the basis of the knowledge gained, assess the significance of gender at all stages of project;
5) make gender visible in project application and project plan; proceed systematically, one project phase at a time, and describe the concrete means and methods for taking account of the gender perspective;
6) plan and implement project so that the gender perspective is taken into account in all phases, and to ensure that the project promotes gender equality in addition to other targets (Haataja et al., 2011) (table 6 (UNIDO, 2015, p. 45)).

The following phases can be indicated in gender mainstreaming (integration) in project activities:

1) assess the significance of the gender perspective in project activities;
2) when the gender perspective does play a role in project activities, at the project planning stage assess the significance of the gender perspective for each project phase;
3) during project implementation, account should be

Table 6: Gender mainstreaming checklist for projects.

Question	**Yes**	**No**	**+/-**
1. Does the project explicitly address a gender issue or issues? If so, please describe how and if not, please provide an explanation.			
2. Does the background/context analysis of the project examine: (a) the different situations of women and men (b) the impacts the project will have on different groups			
3. Will the project collect and use sex disaggregated data and qualitative information to analyze and track gender issues?			
4. Are outcomes, outputs and activities designed to meet the different needs and priorities of women and men?			
5. Does the results framework include gender-responsive indicators, targets and a baseline to monitor gender equality results?			
6. Have adequate financial resources been allocated for the proposed gender activities (vis-a-vis per cent of total budget)?			
7. Are women/gender focused groups, associations or gender units in partner organizations consulted/included in the project?			
8. Does the project ensure that both women and men can provide inputs, access and participate in project activities (target at least 40% of whichever sex is underrepresented)?			
9. Has a gender expert been recruited or do the project staff have gender knowledge and have gender related tasks incorporated in their job descriptions?			
10. Will all project staff be sensitized to gender (online courses, training)?			
11. Is there gender balanced recruitment of project personnel and gender balanced representation in project committees?			
12. Will the monitoring and evaluation of the project cover gender issues and monitor behavioral changes towards greater gender equality?			

taken of the gender perspective throughout the project, in accordance with the project and communication plans. Attention to the gender perspective must be monitored, assessed and reported on throughout the project (Haataja et al., 2011).

The significance of the gender perspective must be assessed at all stages of the project lifecycle (figure 3) (Haataja et al., 2011, p. 44).

5 key steps of gender mainstreaming in PCM:

1) identification – gender analysis;
2) design and planning – gender objectives and indicators;
3) implementation – gender in monitoring;
4) evaluation and monitoring – gender in evaluation;
5) completion – gender in reporting.

How introduce gender mainstreaming in project as a document: project design document (guidance on the kind of information and analysis that you need to apply in order to ensure that your project demonstrates that it meets the needs of both men and women, boys and girls) (Commonwealth secretariat, 2019).

1. Recommendation for project summary: ensure that you reflect in this section the gender implications of the project which you have identified and address by carrying out analysis.
2. Recommendation for background: Identify the position of men and women prior to project development with respect to participation, access and control over resources, norms and values and rights.

   Issues to consider:

   – the government have a statement of political will for enhancing gender equality and basic legislation that prohibits discrimination on the basis of gender;
   – laws or policies well work in practice; who has responsibility for tracking them;
   – the division of labor between men and women at formal, informal, community and family levels;
   – who has access to and control over resources (including time, information, money and economic power and opportunities, education and

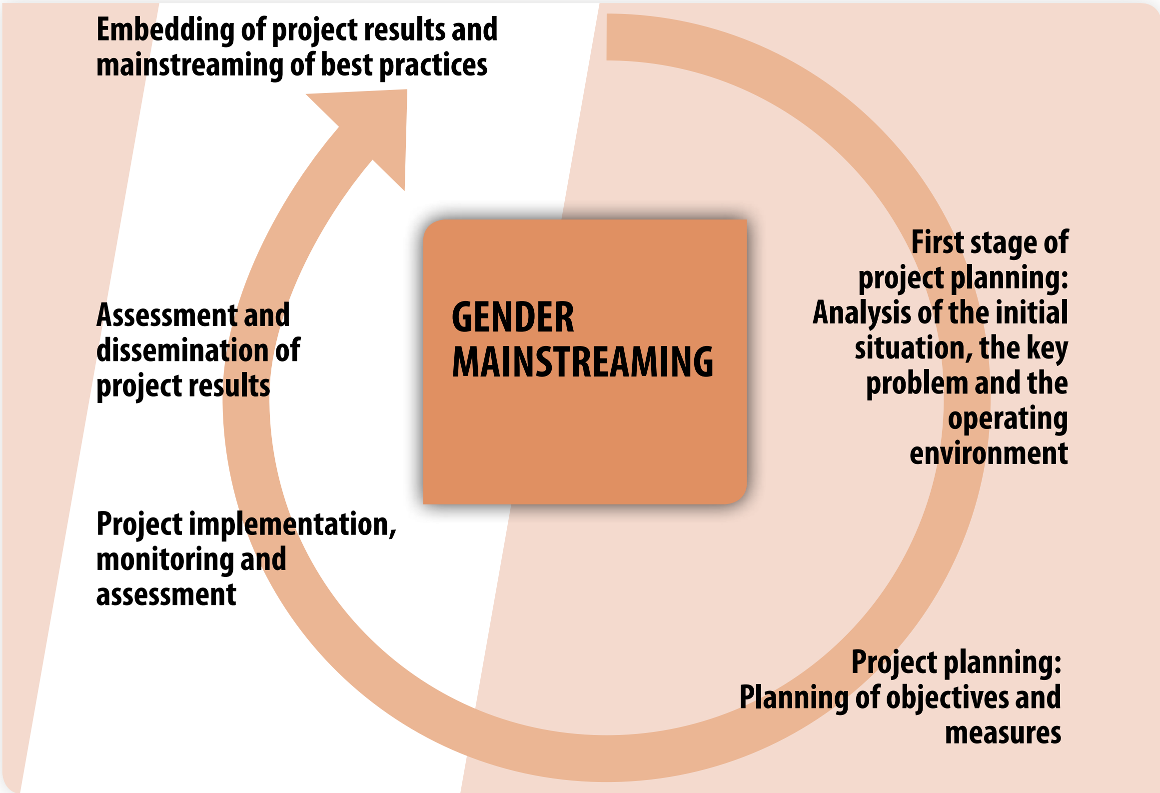

Figure 3: Gender mainstreaming at all stages of a project's lifecycle.

training, work and career, IT and communication, social services, mobility, land and productive resources);

- the barriers to women's participation and productivity and their reasons do they exist; the impact of these for planed project;
- the government implement gender-responsive budgeting (Commonwealth secretariat, 2019).

3. Recommendation for problem to be addressed: identify how your project will impact on women and men differently.

   Issues to consider:

- numbers of men and women equal in terms of the project's target beneficiaries;
- difference in values attached to women and men;
- men and women access to resources in order to benefit from the project;
- gender stereotypes and gendered cultural and social norms and values which affect men and women in the implementation of this project;
- stereotypes and values as an obstacle for men or women in fully enjoying the benefits of the project;
- men and women rights to benefit from the project;
- historical gaps and perceptions which prevent men and women from fully benefiting from the
- does the project challenge the existing gender relations between men and women (division of labor, responsibilities and opportunities);
- taking into account the local contexts and realities (Commonwealth secretariat, 2019).

4. Issues to consider for rationale of project:

- the need for this project should be identified by women or by men;
- the targets (both direct and indirect) of the proposed project; who will benefit–lose; gender-disaggregated data in evidence to identify baseline and gaps for both men and women;
- both women and men in organization, member countries and partner organizations have been consulted on the problem the project is to address; they have been treated with equal respect, as decision-makers, implementers and participants;

- how have women been involved in the development of the project proposal;
- the long-term impact of the project in regard to women's increased ability to take charge of their lives, and to take collective action to solve problems (Commonwealth secretariat, 2019).

5. Issues to consider for beneficiary institutions and lessons learnt:

- how will this project strengthen the institutions directly responsible for gender equality and women's empowerment in the country and civil society organizations;
- how will the project advance partnerships between interested parties;
- how will the project bridge gaps between men and women;
- identified in this area gender gaps, the barriers to women and men benefiting equally from past projects;
- how have these addressed in project;
- practical steps taken to avoid reinforcing stereotypes (Commonwealth secretariat, 2019).

6. Issues to consider for gender mainstreaming.

6.1. What are the gender issues in the central problem that this project aims to addresses:
  - will project challenge current barriers to gender equality or will it reinforce these barriers;
  - will any activities targeted at woman empower them or marginalize them more.

6.2. What results relating to gender equality and empowerment of women will the project produces:
  - will project result in mechanisms being established to increase participation of women in leadership roles and decision making;
  - will project strengthen members' capacities to eliminate violence against women;
  - will project result in women's increased access to economic resources;
  - will this technical assistance and other support be more gender responsive;
  - will policies, systems, budgets and processes have been put in place for gender mainstreaming;
  - will performance monitoring and evaluation mechanisms be more accountable for gender equality.

6.3. What specific strategies will the project use to achieve the proposed results:
  - training for staff and teams on gender analysis;
  - resources and budgets committed to gender equality projects;
  - revision and implementation of policies to reflect gender equality;
  - gender-disaggregated data collected;
  - partnership with international and local women's organizations;
  - identification of gender policy gaps in current project research;
  - gender monitoring structures and reporting mechanisms established/strengthened;
  - gender equality awareness raising (Commonwealth secretariat, 2019).

7. Recommendation for project description: remember all strategic outcomes will have different implications for men and women which is needed to address to ensure a successful outcome for both. Therefore even if the intermediate outcome in project is not gender equality and women's empowerment you need to still include gender specific activities, outputs and short term outcomes in your project.

   Issues to consider:

- how will outcomes address the identified needs of both men and women;
- do outcomes include a broader commitment to improving gender equality and transforming institutions and attitudes that perpetuate gender inequality;
- do planned activities involve both men and women; any additional activities needed to ensure that a gender perspective is made explicit (training in gender issues, additional research, tools provided);
- who will implement the project; have these partners received gender mainstreaming training, so that a gender perspective can be sustained throughout implementation; both women and men participate in implementation (Commonwealth secretariat, 2019).

8. Issues to consider for Logical framework:

- indicators measure the gender aspects of each outcome;
- the indicators are gender-disaggregated and compare the situation of men to women and show an aspect of their relative advantage;
- gender-specific indicators indicate an improvement in women's empowerment.

9. Issues to consider for risk management:

- stereotypes or structural barriers that may prevent one or the other gender from fully benefiting from the project;

- factors which might help the project to promote gender equality and factors which might hinder it;
- how could the attitudes and commitment of the different stakeholders influence the promotion of gender equality;
- planned activities are gender responsive; what needs to be revised (Commonwealth secretariat, 2019).

10. Issues to consider for monitoring and assessment plan:
    - both men and women will be equally involved in the process of monitoring and evaluation; the process will be gender sensitive (Commonwealth secretariat, 2019).

The Logical framework approach (LFA) is a comprehensive methodology to plan, manage, monitor and evaluate a project. It is a core tool required by the EU in project cycle management (van Osch, 2010).

The LFA is a process by which the EU, partner organizations and other stakeholders use a common way of thinking to build, manage and evaluate their projects. The key tool in the logical framework approach is the LogFrame matrix (van Osch, 2010). The LogFrame results from a participative and/or consultative process among stakeholders and is used as a reference tool throughout the project cycle. Drawing up a Gender Mainstreamed Logframe means that gender issues are integrated from the first step. Both women and men should be involved from the start in a participatory process which enhances ownership during the whole project cycle (van Osch, 2010).

The Logframe is a crucial tool to engender the project cycle (table 7) (van Osch, 2010, p. 12).

Quality frame is proposed to be applied for different project stages with gender dimension:

I relevance:

1) consistent with EU policy commitments to mainstreaming gender in development cooperation;
2) consistent with, and supportive of, partner government policies and relevant sector policies, guidelines and regulations;
3) stakeholder analysis/ institutional capacity assessment: evidence that gender specialists and representatives of women's groups have been consulted throughout the process;
4) problems appropriately analyzed: background data/situation analysis disaggregated by age, sex and other factors;
5) lessons learned from previous gender mainstreaming actions are incorporated; linkages made with current and planned gender mainstreaming activities;

II feasibility:

1) objectives and work program linked to gender equality policy objectives; project purpose details how benefits and results are to be enjoyed by men and women, and how this will be measured and verified;
2) clear resources and cost implications, include costs related to gender equality objectives;
3) management arrangements are clear and support institutional strengthening and partner ownership: they reflect gender equality principles, give equal voice to men and women and ensure that inputs are
4) clear monitoring, evaluation and audit arrangements: consistent use of gender-disaggregated indicators; resources for gender-sensitive data collection;
5) identification of risks/risk management to eliminate impact of external factors which can hamper a gender-sensitive overall objective;
6) the project is environmentally, technically and socially sound and benefits are sustainable: (preliminary) relevant information on gender and other social/environmental issues included;

III effectiveness:

1) project remains relevant and feasible to all groups, including women and/or other target groups identified;
2) project objectives are achieved and the results delivered in equitable manner as originally planned (adjustments if relevant);
3) project is being well managed: equal opportunities principles are implemented; gender inequality issues are reflected in project reports, and corrective actions taken; information is gender-disaggregated;
4) sustainability issues are being effectively addressed so that gender equality achievements are maintained and built upon beyond the life of the project;
5) good practice principles of project cycle management, including in gender mainstreaming, are applied by project management tools like Logframe approach (van Osch, 2010).

Table 7: Engendering the Logframe.

Stage	The Logframe matrix context
Identification	It is used to help stakeholders to analyze the problems of different groups and to identify the best solutions for ensuring equal rights and benefits for men and women.
Formulation	It is used to formulate project plan with objectives which reflect a gender perspective, measurable results based on gender-disaggregated data, resource allocations based on gender responsive budgeting, management strategy and responsibilities which enhance gender equality.
Implementation	It is used to ensure equal rights, opportunities and benefits for men and women who participate in the project and/or who are to benefit from the project; to internal monitoring by target groups and for gender aware external monitoring.
Evaluation	It is used to evaluate the gender specific performance, results, outcomes and impact of the project.

6 PROSPECTS FOR WOMEN AS PROJECT MANAGERS AND ENGENDERING TRAINING OF PROJECT MANAGERS

A strategic response prioritizing diverse talent as a key resource for delivering successful projects has been seen as a mean to ultimately increase women's participation at all levels of project, program and portfolio management. A five key elements strategy is proposed and advocated (table 8) (Okoro, 2016).

Another way to increase women participation in project management at all levels could be achieved through dedicated programs that focus on specific goals (so called diversity programs) (Hunt et al., 2015). These programs could be designed to raise the representation of women in project-oriented organizations as well as in particular projects. McKinsey has identified techniques that can be used to enhance the effectiveness of diversity programs (Hunt et al., 2015).

Identifying and sharing good practice could be another way to increase role and participation women in project management for three reasons:

1) increasing visibility of women project managers at all levels of their careers as well as their professional achievements would create positive role models;
2) interactive experience and supporting networks;
3) creating the right context for diverse talent to thrive (Okoro, 2016).

Some employers provide brilliant examples of good practice. BAE Systems (a company with a large cohort of project managers and ranked fourth in The Times top 50 Employers of Women) have a five strand vision on diversity and inclusion that attracts, supports and retains its employees (Okoro, 2016).

The good practice should be shared and promoted by wide range of stakeholders (groups, educators and employers/employees who together can change behaviors and culture). This is especially important task and priority for leadership with influence in professional institutions, organizations or groups to formulate strategy as well as prioritize and champion considered initiatives.

Powerful project management organizations already advocate ideas of empowering women in project management. Australian Institute of Project Management (AIPM) have identified "the eight imperatives" that Australian governments, society, AIPM members and project management industry need to address to remove the barriers to women's progression generally, and project management careers in particular:

1) valuing women;
2) workforce participation;
3) affordable childcare;
4) flexible work;
5) industry and occupational segregation;
6) gender pay gap;
7) superannuation gap;
8) workplace psychological safety (Australian Institute of Project Management, 2020).

Researchers determine the following conditions for success these initiatives and interventions:

– the intervention must be part of a "coherent plan" with sufficient time schedule and resource;
– the company (projects) must have an inclusive culture;

Table 8: Strategic approach "Diverse talent".

Key elements	Main points
Leadership	Vision Communication Embedding change
Processes	Inclusive Flexible, not stifling Resolve bottlenecks
Culture	Culturally intelligent Emotionally intelligent "Investors"
Innovation	Multiple entry routes including career changers Spot and encourage Welcome and reward
Nurturing	Explicit and fair progression routes Challenging opportunities Developing talent

– the intervention frame should be designed in a way that shapes all employees;
– initiatives should seek to transform or challenge the balance of power in an organization (projects);
– the approach should be intersectional, complex; challenging the base of privilege;
– the interventions should call for the reflexivity of participants and individuals experiences within a wider context of societal inequality (Pritchard and Miles, 2018).

Nowadays there is a tendency to increase the participation of women in the management generally and in project management particularly (Bielińska and Osbert-Pociecha, 2018). Women project managers develop their networks (both formally and informally) for support, visibility and encouragement (Henderson et al., 2013). One example of the initiatives is Celebrating Women in Project Management by Elise Stevens. By her own words she provides "a channel for women's voices to be heard, supported and embraced in project management" through creating network of female project managers (Stevens, 2021).

The main consideration on why do we have to promote gender mainstreaming in University:

– legal requirements and commitments (international, national and regional levels) when governments have signed on to international human rights standards and have a duty to protect and promote the human rights of men and women;
– gender equality is now a widely accepted marker for international donors and agencies and is therefore a requirement for building credible and sustainable partnerships (Commonwealth secretariat, 2019).

While authorities and project actors must themselves engage in the development of work processes, development can be supported by means of training and consulting. According to the Action plan for the implementation of the Government of Ukraine's Commitments under the Biarritz Partnership for gender equality, approved by the Government, the Ministry of Education and Science of Ukraine is responsible for ensuring the implementation of the gender equality principles in education namely:

– development and approval of the Strategy for the implementation of gender equality in the field of education until 2030;
– approval of the action plan for the implementation of the Strategy for the implementation of gender equality in the field of education until 2030;
– introduction of anti-discrimination examination of educational content;
– gender audit of educational institutions (Cabinet of Ministers of Ukraine, 2020).

Therefore the gender mainstreaming in education becomes an important issue to be considered.

Gender training is an important tool for gender mainstreaming. It provides people with awareness, knowledge and practical skills about gender equality that help them reflect on and change their self-perception, their ways of relating to others, their beliefs, their problem-setting and problem-solving skills, and their competence and knowledge. It also motivates people to implement gender mainstreaming and to work towards gender equality (Frei and Leowinata, 2014).

How training contributes to gender equality:

- training has led to notable outcomes at the personal/individual level for the participants involved (changes in attitudes and practices concerning gender in/equality and related issues; increased the skills and confidence of participants, which has facilitated the increased participation and representation of women in the public sphere and formal politics; advanced the capacity of participants to integrate gender into their work, as well as strengthening their advocacy skills in gender equality);
- changes can also be noted at the institutional level (generated "change agents", causing a multiplier effect which helped to institutionalize knowledge from the training; increased the capacity of partner organizations to conduct gender analysis, facilitate training and provide technical assistance in the area of gender equality; the tools developed during training sessions have often raised awareness of gender issues in institutions and increased the value accorded to gender mainstreaming by senior management) (Ferguson et al., 2016, pp. 14-15).

Four key themes for analysis and further discussion:

1) diverse nature of training for gender equality (its characteristics and impact vary widely; there is no one "type" of training for gender equality; trainings differ in their lengths, the modalities they use, and the kinds of objectives they pursue);
2) the importance of theory of gender and theory of change adopted which profoundly shapes the objectives and outcomes of training;
3) training's embeddedness in long term change projects (training should be structurally embedded in such processes, leadership and management commitment, conducive political institutional context and follow-up initiatives to sustain the institutionalization of knowledge from training);
4) budgets issue (the implementation of regular or more wide-ranging trainings require additional, specifically-directed funds) (Ferguson et al., 2016).

To enable longer-term results (long-term changes in individual attitudes and institutional practices), measures beyond training are required. It needs to incorporate of a gender transformative approach in project design, research, articles, and tools (Ferguson et al., 2016). Therefore, other measures focused on achieving and supporting sustained results are also necessary, like as:

- establishment of radio programs and channels for women;
- advocate for local policies and budget allocations for gender equality and women's empowerment therefore advocacy theme could be introduced as a part of studying disciplines or as separate course;
- created a network of self-help groups for female project participants.

7 CONCLUSIONS

Despite the tendency to increase participation of women in project management they are still underrepresented and project manager marks as nontraditional job for women. Women working as project managers usually are not assigned to significant role and mega-projects. Beyond managing complex projects, women face the added challenges of having to prove their credibility many times over and in multiple ways.

Indications of maintained marginalization of women in project management: low level of women participation in project management; mostly insignificant role of women as project managers (usually female managers were assigned less ambitious, less complex and lower risk projects).

In the context of skills gap in project management the role and participation of women could be crucial. The strategies to increase women role as project managers should be developed and promoted by wide range of stakeholders (groups, educators and employers/ employees) with special emphasizing on championship of professional institutions, organizations or groups.

Achieving sustainable and lasting changes in communities projects development for the benefits of men and women requires the introduction of a gender mainstreaming at all stages of the project cycle. Project managers must be trained and given a set of techniques and skills for the practical implementation of gender mainstreaming in their activities. An important role in this process can and should be played by educational institutions for the introduction of special training and courses on gender mainstreaming in project management.

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Development of Heads' Personal Readiness of Vocational Education Institutions for Managerial Activity in the Conditions of Distance Postgraduate Education

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Keywords: Personal Readiness, Heads of Vocational Education Institutions, Management Activities, Digitalization, Educational Space, Distance Postgraduate Education.

Abstract: The article highlights the problem of psychological features of heads' personal readiness of vocational education institutions to manage in the context of digitalization of educational space. The personal qualities of vocational education heads, significant in the context of the introduction of digital technologies of vocational training, are highlighted. The psychological features of adult education in general and postgraduate education, in particular, are determined. Specific problems of distance learning and distance postgraduate education are highlighted. The results of an empirical study of the peculiarities of the manifestation of indicators of heads' personal readiness to manage in the context of digitalization are presented. Difficulties in the manifestations of entrepreneurial activity, in assessing their effectiveness, the predominance of egocentric orientation, differentiated attitude to others concerning the subjective, situational factors, limiting the focus on creating a creative digital educational environment in a large number of respondents were outlined. An insufficient general level of heads' personal readiness of the system of vocational education for management in the conditions of digitalization is stated. Psychological means of promoting the development of heads' personal readiness of vocational education institutions for management activities in the conditions of distance postgraduate education are determined. The program of development of heads' personal readiness of institutions of professional education to administrative activity in the conditions of distance postgraduate education is covered. The results of the analysis of the effectiveness of the program for the development of heads' personal readiness of vocational education institutions for management activities in the process of psychological training in the conditions of distance postgraduate education are presented.

1 INTRODUCTION

Taking into account the current education global trends, the complex epidemiological situation, the introduction and duration of quarantine restrictions, which stimulated the transition to distance learning and remote work of educational institutions employees, improving the management of educational organizations in distance learning, has become extremely important (Shokaliuk et al., 2020; Bobyliev and Vihrova, 2021).

At the same time, the issues of introducing e-distance learning technologies in the practice of edu-

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cational organizations at all levels are becoming more and more relevant as a result of the formation of a digital society on the principles of open education, creating a flexible personal educational environment following the individual educational trajectory (Andros et al., 2019; Bykov et al., 2020; Kyslova et al., 2014; Smulson et al., 2012; Spirin and Vakaliuk, 2019).

The immediate information and educational space are gaining active development, providing adults with an increasing variety of electronic educational resources and digital learning tools, radically changing the possibilities of education, in general, and professional, in particular.

At the same time, the analysis of theoretical sources and educational practice (Bondarchuk et al., 2014) indicates the presence of psychological problems in the process of digitalization of educational space: 1) the need to develop motivation for distance learning, which provides higher activity, self-motivation and self-control of participants; 2) an insufficient level of readiness to search, perceive, assimilate, process information with the help of digital learning technologies; 3) implementation of digital technologies and monitoring of its effectiveness taking into account the psychological characteristics and digital competence of participants in the educational process; 4) difficulties in determining and taking into account the psychological characteristics of students in the organization of distance learning through the absence of direct contact with the teacher.

This necessitates the analysis of the characteristics of personal factors of readiness of heads of vocational education institutions to manage in the context of the digitalization of educational space and on its basis the development and testing of a program for the development of appropriate readiness in the system of distance postgraduate education.

2 LITERATURE REVIEW

The heads' personal readiness of vocational education institutions to manage in the conditions of digitalization of the educational space is a component of their general psychological readiness for professional activity. Effective management of a vocational education institution in today's challenging situation involves taking into account both general (due to the general specifics of management work: informative saturation, diversity of management functions, strict requirements for individual professional qualities and professionalism, etc.) and specific (due to direct conditions) institution: dependence on the impact of inconsistent decisions and recommendations of higher education authorities, a particular contingent of students, inclusive responsibility for the results of activities in the uncertainty of their evaluation criteria, the excess of emotionally charged contacts with different categories of consumers of educational services) (Bazyl et al., 2019; Bondarchuk, 2008; Karamushka, 2004; Pikelna, 1993).

At the same time, scientific research in the field of vocational education is mainly aimed at the development of students, but when it comes to training teachers, attention is focused on improving the methodology of teaching subjects (Faleeva et al., 2017; Grollmann, 2008; Rozendaal et al., 2003; Robertson, 2008; Nychkalo, 2017; Sergeeva, 2015); however, the issue of personality constituents is not well covered, although, in our opinion, they are decisive.

So, the psychological structure of personal readiness as a set of personal qualities of heads of vocational education that are significant for the implementation of management in the context of digitalization of the educational space is made up of the following characteristics: entrepreneurial spirit, self-efficacy, focus on business and constructive communication, an active-positive type of attitude towards other people, and social creativity.

Entrepreneurship, as a professionally important quality of the personality of the head of any industry, determines the effectiveness of managerial functions in changing, complex situations and is characterized by a set of such integrative psychological characteristics as the ability to take a reasonable risk; innovative position in the introduction of new technologies; creative approach to problem-solving; independence of judgments, opinions, actions; flexibility in choosing competitive management strategies; focus on achieving significant results, the desire for continuous self-development (Karamushka, 2004; Kredentser, 2011; Maksymenko et al., 2009; Pachkovskyi, 2006), which, in our opinion, is directly related to the introduction of the modern digital technologies in the educational process.

A vague indicator of the personal readiness of the heads of vocational education institutions for management in the context of digitalization is their self-efficacy, that is, the degree of assessment of their effectiveness, efficiency in specific activities, their perception of their competence (Bandura, 1971; Yanchuk, 2005).

Based on the concept of self-efficacy by Bandura (Bandura, 1971), people who are aware of their self-efficacy, make more efforts to complete difficult tasks than people who have serious doubts about their capabilities. This assumption is also confirmed in the works of modern researchers, which show the relationship between self-efficacy and career success, professional self-realization and professional and personal development (Bondarchuk, 2008; Mogilevkin, 2007; Choi et al., 2011; DeNoble et al., 1999).

Concerning another indicator of personal readiness – personality orientation - -it is worth noting that it characterizes the head through his/her aspirations, beliefs, interests, values, worldview and determines his/her active and purposeful behaviour (Ananyev, 2008; Bozhovich, 2008; Heckhausen, 1967). That is, the orientation of the personality is a complex psychological property, which is a stable system of internal motives and life goals of a person, shows the incentive factors and the vector of its aspirations. Among the main lines of such analysis, the focus on business, communication and oneself is distinguished, while it is this hierarchy of focus that determines the effectiveness of the head's activity (Shchokin, 1993).

The effectiveness of interaction in the process of implementing digital learning technologies is largely determined by the type of leader's attitude towards other people. Indeed, in conditions of uncertainty, constant change and high personal responsibility for the results of the educational organization, the head must show an active-positive type of attitude to other people (according to Gibson et al. (Gibson et al., 1993)), showing respect and acceptance of the inner world of each individual, thereby providing opportunities to realize their potential.

Management activity in the context of digitalization of the educational space is closely related to the social creativity of the individual, assumes the presence of a general ability to self-actualization; the severity of social motivation, which reflects the individual's need for social contacts and motivational attitudes to communicate with other people; the development of social imagination, which allows to model further steps in the situation of social interaction based on feedback (Popel, 2014).

Thus, the professionally important personality traits of the educational organizations heads, which make up the personal readiness to manage the implementation of digital learning technologies, are the basis of successful activities of heads of vocational education in the digitalization of the educational space.

The theoretical analysis of the researched problem allowed implementing the following, empirical, stage of research of the psychological characteristics of the heads' personal readiness of vocational education institutions for management in the context of the digitalization of the educational space and based on it, creating the program of development of corresponding readiness in the conditions of distance postgraduate education.

3 METHODS

The study involved 230 heads of vocational education institutions from different regions of Ukraine, who underwent advanced training in Central Institute of Postgraduate Education of the University of Educational Management during 2019–2020.

The following methods were used: theoretical (analysis and generalization of the results of theoretical analysis of the literature); empirical: Test for general abilities to entrepreneurship (GET TEST, adapted by Y. Pachkovskyy) (Pachkovskyi, 2006); Self-efficacy questionnaire (authors – M. Scherer, J. Maddux, modified by A. Boyarintseva) (Sherer et al., 1982); methods – "Determination of personality orientation" (authors – M. Kucher, V. Smekal) (Nikiforov et al., 2003); "Attitude to the neglected employee" (who is given the least preference) (Least Preferred Coworker, LPC, author – F. Fiedler, adapted by S. Kalishchuk) (Kalishchuk, 2014); "Determination of social creativity of the individual" (adapted by N. Fetiskin, etc.) (Fetiskin et al., 2002); mathematical and statistical (search of primary statistics, analysis of variance ANOVA) data processing was performed using SPSS version 17.0.

The formative stage of the study was implemented in 2020 based on the Central Institute of Postgraduate Education of the University of Educational Management. 49 heads of these institutions from different regions of Ukraine took part in the approbation of the program of development of heads' personal readiness of vocational education institutions for management in the conditions of distance postgraduate education, of which 24 persons made experimental group and 25 – control group.

The program provided the use of modified for its tasks and adapted to the distance form of the advanced training group and interactive methods: training in a virtual learning environment, group discussions and "brainstorming" in chat, work in small groups using messengers, interactive mini-lectures, role and business games, method of incomplete sentences, analysis of managerial situations, project and individual creative tasks, etc (Smulson et al., 2012; Bondarchuk et al., 2014; Kredentser, 2011; Kazakova, 2020; Lukyanova et al., 2012).

Statistical processing of the results of approbation of the program "The development of heads' personal readiness of vocational education institutions for management activities in the digital educational space" was carried out according to the same methods as at the statement stage of the study using SPSS version 17.0.

4 ANALYSIS OF THE RESEARCH RESULTS

We conducted an empirical study aimed at studying the psychological characteristics of the heads' personal readiness of vocational education institutions for management activities in the context of digitalization of the educational space. The logic of the analysis was carried out by the selected indicators of the studied readiness: entrepreneurship, self-efficacy, focus and constructive communication, active-positive type of attitude towards other people, and social creativity (Kazakova, 2020).

The results of the empirical study revealed the predominance of the following entrepreneurial characteristics, significant in the context of new challenges of educational organization management in terms of digitalization of educational space: the need for autonomy ($M = 7.9; \sigma = 2.1$), which is manifested in purposefulness, and sometimes in stubbornness, independence in doing the activity and decision-making; focus on reasonable, weighted risk ($M = 7.4; \sigma = 1.9$), which includes the ability to accept the consequences of their choice, see the benefits of mistakes, act in a situation of uncertainty, and the ability to be creative ($M = 7.1; \sigma = 1.4$), consisting of the sensitivity of heads to new experiences, prone to non-trivial solutions. The least represented were the needs for achievement ($M = 6.8; \sigma = 1.7$) and determination and determination ($M = 6.7; \sigma = 1.9$), which indicates a lack of self-confidence, a tendency to rely more on external factors than on their actions.

Besides, the distribution of heads of vocational education institutions depending on the level of their ability to entrepreneurship was revealed (table 1).

Table 1 shows the vast majority of respondents have an average level of entrepreneurial ability (78.3%), and a low level – 16.5%. Instead, only 5.2% of heads have a high level of entrepreneurial skills.

At the same time, according to the results of analysis of variance, a statistically significant relationship ($p < 0.01$) between the indicators of entrepreneurial activity and the age category of heads depending on gender, which showed that heads of the younger cohort (up to 45 years) have a more pronounced ability to entrepreneurship. Groups of senior men-heads and women, regardless of age, show reduced indicators of entrepreneurial characteristics. The presented results coincide with other studies that emphasize the predominance of male models of entrepreneurial behaviour, which negatively affects the perception of their entrepreneurial abilities in women (Sullivan and Meek, 2012).

So, the identified ambivalence and insufficient level of development of entrepreneurial characteristics of heads of vocational education institutions can negatively affect the management of innovative development of the organization in general and the effectiveness of the implementation of digital learning technologies in particular.

The next stage of the study was aimed at determining the characteristics of heads' self-efficacy of vocational education institutions (table 2).

As the data of rable 2, the level of activity self-efficacy of heads is slightly higher than social (7.4 and 6.4 points on average, respectively). Comparison of the results of other studies (Bondarchuk, 2015) allowed to state slightly lower indicators of self-efficacy in the studied heads of vocational education institutions, in contrast to the heads of secondary schools.

Also, we revealed an insufficient level of self-efficacy of heads: 30.4% of respondents have a high level, 40.9% have an average level, and 28.7% have a low level, which may indicate a low assessment of their capabilities of the vast majority of heads in achieving their goals, comparing one's achievements with successes, social norms and assessments of other people.

According to the theory of self-efficacy (Bandura, 1971), this phenomenon was considered as a leading personal construct that forms a belief in their success and effectiveness of actions in one or more activities. Following the researcher, even the presence of high personal potential does not automatically guarantee the achievement of high results if a person does not have faith in the ability to influence the events of his/her own life. Conversely, even with insufficiently high abilities, but high self-efficacy a person can achieve significant success. Therefore, of course, the development and maintenance of confidence in the self-efficacy of heads of vocational education institutions will positively affect their psychological readiness to overcome life's difficulties, frustrations and stresses that arise during management in the digitalization of educational space.

Further analysis of the results obtained by the method of M. Kucher and V. Smekal revealed the peculiarities of the orientation of heads.

So, it is established that in the hierarchy of orientation, on average, heads tend to focus on business (27.6 points on average), then on interaction (27.3 points on average), and then – on themselves (26.3 points on average), which coincides with the ideas of the authors of the methodology of the hierarchy of orientation, which increases the efficiency (Shchokin, 1993).

At the same time, a detailed analysis of the methodology showed that such a hierarchy is not

Table 1: Distribution of heads of vocational education institutions by levels of ability to entrepreneurship.

Levels of ability to entrepreneurship	Number of respondents, %
Low	16.5
Average	78.3
High	5.2

Table 2: Features of self-efficacy of heads.

Types of self-efficacy	Points, on average	Σ
Activity	7.4	0.9
Social	6.4	1.3
General	6.9	0.9

common to all heads (table 3).

Table 3: The results of cluster analysis of indicators of personality orientation of heads of vocational education institutions.

Personality orientation	Clusters		
	1	2	3
For business	30	27	27
For interaction	26	25	30
For themselves	24	29	25

As follows from the data given in table 3, the first cluster (21.8%) consisted of heads with the optimal hierarchy of orientation ("for business" – "for interaction" – "for themselves"), namely a high level of personality orientation. Such leaders are interested in constructive solutions to business problems, support the teaching staff and individual employees on the way to the goal, encourage them to express their opinions and beliefs, while taking responsibility for the case, trying to help solve problems together, able to defend their opinions and hear the position of others to achieve a common goal.

The second cluster (39.1%) includes respondents with a predominance of self-orientation, which indicates a low level of personality orientation of heads. Such heads are focused primarily on direct remuneration and satisfaction of their own needs, desires, interests, regardless of the current situation and needs of the institution. In case of limitations, these opportunities may be anxiety, irritability and aggression. This category of heads is often focused only on themselves, their feelings and experiences; ignore the needs of the interests of subordinates and colleagues, try to impose their views on the team, and tend to make hasty and unfounded conclusions about others, and so on.

The third cluster (39.1%) included heads with a predominance of interaction orientation and, accordingly, with an average level of orientation of their personality. Such leaders focus primarily on effective interpersonal interaction and joint activities, the interests of the teaching staff, which may sometimes interfere with the effective implementation of production tasks. Heads with such a focus are mainly focused on social acceptance; depend on the group and team; feel the need for support and commitment of others, as a result, may give in to pressure from the team or group of employees, regardless of their ability to problem-solving and solve production problems for the sake of maintaining friendly relations.

At the next stage of the empirical study, the peculiarities of the manifestation of the types of the heads' attitude of vocational education institutions with other people were analysed(table 4).

Table 4: Type of installation of heads of vocational schools with other people.

Type of installation	Number of respondents, %
Situational-subjective	44.3
Functional & business	22.6
Hidden-negative	17.4
Neutral-indifferent	14.8
Active-positive	0.9

As evidenced by the data in table 4, the majority of heads of vocational education institutions found an insufficient level of positive attitude towards other people.

So, the active-positive type of installation as a professionally important quality of specialists such as "person-person" is characteristic of only 0.9% of respondents. Representatives of this group show a friendly attitude to others, willing to notice first of all their positive qualities, which, in turn, creates an atmosphere of friendliness, mutual understanding and cooperation. This type of attitude is especially relevant in the situation of distance learning, limited direct contact of participants in the educational process to increase the level of psychological security of the digital learning environment.

At the same time, a significant number of heads (44.3%) are characterized by a situational-subjective type of attitude towards other people, which causes a tendency to differentiate their attitude to others depending on their emotional state and feelings of acceptance by others; and also leads to sharp mood swings under the influence of situational factors and subjective factors. 22.6% of the surveyed heads have a functional-business type of attitude, which is manifested in a differentiated attitude towards people consistent with their usefulness when friendliness is shown only about “necessary” people. The survey stated that neutral-indifferent type of attitude towards other people have 14.8% of respondents and is manifested in secrecy, lack of sincerity to others; communication is formally polite but emotionally alienated and superficial. Heads of latent-negative orientation (17.4% of respondents) show a tendency to notice and emphasize mostly negative traits, qualities in others, intolerance of these people, openly demonstrating their negative attitude, which creates mutual hostility and malevolence.

As the analysis of the results of the study showed the peculiarities of the type of heads’ attitude of vocational education institutions to others, only 0.9 % of surveyed heads are characterized by a high level of attitude towards other people, 67.0 % – medium, and 32.1 % – low (table 5).

So, the type of attitude towards other people is one of the problem areas in the context of heads’ personal readiness of vocational schools for management activities in the context of digitalization of educational space.

It is clear that with this type of attitude of heads, the development of motivation for staff professional development of educational organizations in general, and the introduction of digital learning tools is quite problematic.

An important indicator of heads’ personal readiness of vocational schools to manage in the digitalization of educational space following the author’s approach is the heads’ social creativity of vocational (professional) schools, to determine which used the appropriate method of Fetiskin et al. (Fetiskin et al., 2002).

By the results of empirical research, an insufficient level of social creativity was found in a rather large group of surveyed heads (table 6).

As evidenced by the data presented in table 6, a low level of social creativity was found in 28.7%, average – in 43.5%, and high – in 27.8% of respondents.

Thereby, a significant number of heads of vocational education institutions are characterized by a lack of creativity in the social sphere, they have difficulty in constant social contacts and motivational attitudes to communicate with other people; limited in the manifestations of social imagination, which allows predicting and modelling behaviour in situations of interpersonal interaction based on feedback, etc. This may indicate certain limitations in creating a creative digital educational environment, on the one hand, due to the specifics of virtual interaction, and, on the other - due to the position that inhibits social interactions, because heads themselves are not able to show an example of creative interpersonal interaction, to be the creative environment carrier.

Summarizing the results according to all methods, we identified the levels of heads’ personal readiness of vocational education institutions to manage in the context of digitalization of educational space (figure 1).

Figure 1 presents that the heads’ personal readiness of vocational education institutions to manage in the conditions of digitalization of the educational space is insufficiently formed.

Hence, a high level of such readiness was found only in 20.4% of the surveyed heads, who are characterized by high levels of entrepreneurial activity, self-efficacy, social creativity; predominant focus on business and communication as well as an active-positive type of attitude towards other people.

The average level is set at 63.0% of heads, which are characterized by the following: mostly average indicators of entrepreneurial activity, self-efficacy, and social creativity; predominant focus on interaction, situational-subjective or functional-business types of attitude towards other people.

A low level was found in 16.6% of respondents, who found low levels of entrepreneurial activity, self-efficacy, social creativity; predominant self-orientation as well as neutral-indifferent or hidden-negative types of attitudes towards other people.

Therefore, based on the results of empirical research, an insufficient level of both indicators of heads’ personal readiness of vocational education institutions for management in the context of digitalization of the educational process and its general level were established, which actualize the need to develop and test a program for psychological support of their personal readiness in conditions of distance postgraduate education.

4.1 Distance Postgraduate Education

Despite the rapid pace of social changes and scientific and technological progress, it became necessary to revise approaches to postgraduate education with the practice of organizing periodic courses at a certain time interval between attending refresher courses by specialists, since this format limits the development of a personality that can not only perceive changes as an objective reality but also initiate innovation and training, adequately solve the problems of our time, respond to them, predict and change social reality.

Equally important is the awareness and consider-

Table 5: Distribution of heads of vocational education institutions by levels of the type of attitude to others.

Levels of attitude towards others	Number of respondents, %
Low	32.1
Average	67.0
High	0.9

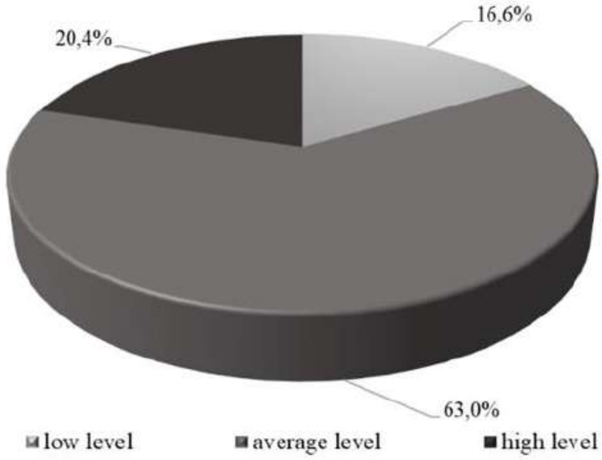

Figure 1: Distribution of heads of vocational education institutions by levels of personal readiness to manage in the context of digitalization of educational space.

Table 6: Levels of heads' social creativity of vocational schools.

Levels of social creativity	Number of respondents, %
Low	28.7
Average	43.5
High	27.8

ation in the process of distance postgraduate education of the specific features of adult learning based on their professional experience; value attitude of listeners to reality, indicators of heads' personal readiness for managerial activity in the conditions of digital educational space (Smulson et al., 2012; Bondarchuk, 2014; Knowles, 1980; Conceptual bases of adult education development, 2018; Putsov, 2010; Eynon and Malmberg, 2020; Lukyanova, 2019).

Therefore, postgraduate education ceases to perform only the traditional function of training and retraining, it becomes a stage of adult development aimed at improving professional activity and the development of professional competence throughout life.

The specific features of adult education is a complex of systematised factors of the educational process subjects from the standpoint of the andragogical approach, which includes: the role of the subjects of learning and the peculiarities of their interaction as equal partners; organization of the learning process based on joint activities, individualization and self-determination; active and interactive teaching methods aimed at improving the quality of education, professional and personal growth of adults; the specifics of educational programs based on the principle of continuity, expediency, prospects; orientation of the motivation of learning to meet the practical problems of the practice of professional activity of specialists; use of life experience, etc (Andros et al., 2019; Bondarchuk, 2015; Conceptual bases of adult education development, 2018; Lukyanova, 2019).

The importance of postgraduate education in modern circumstances is due to the changing needs of the labour market, the content and nature of work aimed at developing professionals in the context of bringing their professional skills in line with world standards, time requirements, personal and industrial needs, improving their scientific and cultural level, stimulation and development of the creative and spiritual potential of personality (Bondarchuk, 2015; Lukyanova, 2019; Sorochan, 2002).

An important feature of postgraduate education is its prognostic nature, because the learning process should, on the one hand, respond quickly to trends and prospects of education and the latest advances in science, and on the other – to widely disclose practice-oriented training technologies students to respond to challenges in professional activities.

All these aspects remain relevant during the introduction of anti-epidemic measures in our country and around the world, related to the spread of COVID-19, which encouraged educational institutions at all levels to make a mass transition to distance learning. At the same time, the active introduction of distance learning in postgraduate education necessitates the organization of effective interaction of students in the virtual educational space as a systematic and effective joint activity based on ICT.

This helps to highlight the specific features of distance learning, among which are the following advantages: the ability to vary both asynchronous and synchronous interaction with all partners belonging to the virtual community; association of participants of interaction in joint activity on the transformation of certain objects that have for them subject-practical and cognitive value; the emergence of new motivating factors of virtual interaction, in particular, the novelty of the proposed work forms, which creates a sense of belonging to advanced technologies, reinforces the desire to be modern.

It is also necessary to take into account the problems in the organization of distance learning, including the following: the presence of psychological barriers in some heads (especially older people) when working with a computer; insufficient level of competence in the implementation of ICT of a significant number of teachers and students; insufficient level of psychological and pedagogical competence of the postgraduate education system teachers regarding the organization of virtual interaction, etc.

At the same time, psychological and pedagogical developments in the field of distance learning and distance education, the creation of virtual educational space correspond to modern issues of lifelong learning as a psychological and pedagogical condition of self-development (Andros et al., 2019; Balyk et al., 2019; Bondarchuk, 2014; Bykov et al., 2020; Smulson et al., 2012; Spirin and Vakaliuk, 2019).

This approach allows talking about the fundamental possibility of developing in the conditions of distance postgraduate education the heads' personal readiness of vocational education institutions for management activities in the digital educational environment.

The results of the implemented empirical study revealed an insufficient level of both indicators of heads' personal readiness of vocational education institutions to manage in the context of digitalization of the educational process, and the level of their readiness in general.

Difficulties in the manifestations of entrepreneurial activity, in assessing their effectiveness, the predominance of egocentric orientation, differentiated attitude to others concerning the subjective, situational, useful factors, limiting the focus on forming a creative digital educational environment in a large number of researchers, which highlighted the need to develop approbation of the program of development of heads' personal readiness of vocational education institutions to management in the conditions of digitalization of educational space in the system of distance postgraduate education.

To identify the factors that hinder the effective implementation of the process of heads' personal readiness of vocational education institutions to manage management in the digital education space, it should be noted that although the overwhelming majority of heads understand and share the importance of introducing digital management technologies, this process is sometimes chaotic, unsystematic in nature, besides, many heads have a low level of initiative, enterprise and other psychological qualities that are important for successful management activities in the context of digitalization of the educational space.

4.2 Description of the Program

The purpose of the formative stage of the experiment was to design and experimental verification of the effectiveness of the program for the development of personal readiness of heads of vocational education institutions to manage in the context of distance postgraduate education.

The developed program was based on a conceptual model of promoting the personal development of specialists in the process of postgraduate education (Bondarchuk, 2008), according to which the development of heads' personal readiness of vocational education institutions for management in the digital education space is carried out in four stages.

1. The preparatory stage, which actualized the heads' desire to develop personal readiness for management activities in the digital educational environment.

So, the preparatory stage of the work included: an acquaintance of group members; determining the purpose and objectives of the special course; expression by heads of expectations from participation in a special course; discussion and approval of work rules; setting up activity and improving efficiency; creating a comfortable atmosphere of interaction in a virtual learning environment.

For this purpose, at the beginning of each meeting, various forms of activity were used: self-presentations, icebreakers, voicing actual well-being and psycho-emotional state, exercises, etc.

This was achieved through the use of, for example, icebreaker exercises "I did not expect myself to…", modified and adapted for distance learning exercises "Ball" and also exercises "Treasury of associations" and the modified variant of brainstorming "Pros and cons of digitalization of educational space", etc.

2. Diagnostic stage aimed at the disclosure and awareness of heads of personal characteristics and their reflection in the results of professional activities.

At this stage, a psychological workshop was conducted using the following methods: Test for general abilities to entrepreneurship (GET TEST, adapted by Y. Pachkovskyy) (Pachkovskyi, 2006); Self-efficacy questionnaire (authors – M. Scherer, J. Maddux, modified by A. Boyarintseva) (Sherer et al., 1982); methods – "Determination of personality orientation" (authors – M. Kucher, V. Smekal) (Nikiforov et al., 2003); "Attitude to the neglected employee (who is given the least preference" (Least Preferred Coworker, LPC, author – F. Fiedler, adapted by S. Kalishchuk) (Kalishchuk, 2014); "Determination of social creativity of the individual" (adapted by N. Fetiskin, etc) (Fetiskin et al., 2002).

3. Developmental stage, in which the development and correction of components of heads' personal readiness for management in the digital educational space, using the following methods:
   - analysis of managerial situations, when participants consider problematic situations of managerial activity during the digitalization of educational space, the constructive solution of which is possible provided that there is a high level of appropriate personal readiness of the heads of vocational education institution;
   - group work to actualize the desire to help improve the management of the educational institution by personal example through exercises: "My life credo", "Who am I? What am I?", "Portrait of the head of a vocational education institution", etc.;
   - business game "Vocational education institution: yesterday, today, tomorrow", which helps to comprehend the existing experience and agree per the requirements of the time;
   - role-playing games "Guess the style of communication", "Psychological strategies to achieve results during the online meeting".
4. Prognostic stage aimed at identifying and developing vectors, forms, methods and ways of further development and self-development of heads' personal readiness of vocational education institutions for management activities in the digital educational environment.

The means of implementing the final stage were special tasks for independent work, exercise "Wish Basket" (members of the training group wished each other in the form of proposals "gifts" that provide an opportunity to improve the heads' personal readiness of vocational education institutions to manage in the digital educational space), and also reflective analysis "What did the training give me?".

The final stage of the program was focused on summarizing the work, filling out a feedback questionnaire, which is expected to answer the following questions:

I. Have you participated in such events before?

II. Did your expectations for the special course come true?

III. What did you like most about the tasks?

IV. Did you receive new information about your personal qualities? If so, which ones?

V. Have there been any changes with you as a result of participating in the special course and if so, which ones?

VI. Have you gained any useful knowledge? If so, which ones?

VII. Do you plan to use the acquired skills in your professional activity?

Hence, taking into account the results of the ascertaining stage of the study, the list of principles (professional development of heads of vocational education institutions, focus on self-knowledge and individual' self-development, use of active group teaching methods, creative activity, partnership) and psychological conditions (creation of a special social environment of comfort and creative freedom, mutual support in the group, trust, respect, activation of adequate self-perception through reflective analysis), which contribute to the development of heads' personal readiness of vocational education institutions to manage in the digital educational environment in distance postgraduate education.

Specific features of such a social environment in terms of distance learning are:

1) the organization of virtual joint activities of heads of vocational education institutions, during which they realize themselves as creative individuals; meet higher human needs; at the same time through the organization of joint, interdependent activity there is an effect of group feeling of usefulness for another with raising of self-worth;

2) joint formation of group norms and principles of interaction of humanistic orientation in the virtual learning environment, among which was voiced the establishment of partnerships during participation in the program, sincerity, emotional openness and trust in each other, acceptance of another person as a value; tolerance, positive attitude, lack of criticism, active involvement in the group creative process;
3) social and spiritual enrichment in remote joint activities, the joint experience of a sense of belonging to the peculiarities of professional culture, discussion of issues of professional self-determination, the mission of the head of vocational education, etc.;
4) intensification of mental, emotional and behavioural components of joint activities through collective action in the digital learning environment with a public demonstration of results, such as project activities;
5) establishing feedback in the process of joint activities between its participants (chats, conversations, group forms of communication, etc.) to ensure the process of self-awareness with the help of others;
6) implementation of a system of special tasks that determine the acceptance and playing of a social role (head of a vocational education institution) with certain characteristics that correspond to a person focused on improving management in the digitalization of the educational space (Krylov, 2000).

The next task of the formative stage of the experiment was to identify and develop adequate and optimal forms and methods of work that would best meet the objectives of the study and take into account the features of distance postgraduate education. Herewith, we took into account that the heads' training methods of vocational education institutions should be characterized by efficiency and practicality, encourage constructive communication, promote the ability to solve management problems in the digital educational environment, stimulate new ideas, develop heads' ability to self-knowledge and self-understanding, cultivate tolerance, respect for the individual characteristics of each person.

The choice of the most optimal forms and methods of training of heads of vocational education institutions was based on the fact that they should be characterized by efficiency and practicality, encourage constructive communication, promote the ability to solve management problems in the digital environment, be open to new ideas and active in their implementation, develop the ability of heads to self-knowledge and self-understanding, cultivate tolerance, flexibility, and respect for the individual characteristics of each person (Bondarchuk et al., 2014; Kredentser, 2011; Kazakova, 2020; Bondarchuk, 2015).

Based on our practice and the specifics of adult education in the process of distance learning in modern conditions, we believe that it is appropriate to apply adapted to distance learning group and interactive methods: training in a virtual learning environment, group discussions in video conferences and "brainstorming" in chat, work in small groups in the created rooms of the distance learning environment, interactive mini-lectures using multimedia presentations, role and business games, method of incomplete sentences, analysis management situations and their discussion, project and individual creative tasks, etc (Bondarchuk et al., 2014; Bondarchuk, 2008; Karamushka, 2004; Kredentser, 2011; Mogilevkin, 2007; Kazakova, 2020).

The main form of implementation of the program of heads' personal readiness to manage in the digitalization of educational space was chosen training, because of its focus on the practical development of material, when in the process of modelling specially set situations students have the opportunity to develop and consolidate the necessary knowledge and skills, experience and approaches used in the work, understand the state of development of personal readiness and identify its psychological problems, personal qualities, features of interaction with others. With the help of training exercises in a virtual learning environment, heads learn the features of remote perception by others of their personal qualities, behaviour, managerial actions. Overcoming psychological difficulties, correction of restrictions, correction of shortcomings in interactive interaction at a distance are carried out; ways of his/her personal growth are developed.

Inclusion in the program group discussions in chat capabilities used for updating the free exchange of digital learning environments thoughts, ideas and knowledge between stakeholders to provide feedback, reducing resistance to adopting the opposite position through group reflection, eliminating bias in assessing others through public statements, enabling heads to demonstrate their competence by meeting the need for respect and recognition.

The use of group discussions contributed to the development of motivation to use such a technique in managing a vocational education institution, expanding ideas about the possibilities of interpersonal interaction and creating effective team cooperation in a virtual environment, expanding and deepening knowledge about the peculiarities of heads' personal readiness to manage of the educational institution in the context of digitalization of the educational space, updating aspirations to improve the management efficiency of their educational institution, to strengthen the desire to implement innovative forms and methods of personality development, to understand the conditions and ways of developing personal qualities that are important in the context of the digitalization of the educational space.

Besides, we took into account the fact that the use of group discussions in training, following the Pakhalyan (Pakhalyan, 2006) opinion, promotes empathy, allows noticing in each unique and original personality, changes the attitude of participants to others through the emergence of new active social interactions, which becomes especially relevant in the digital educational environment.

To expand the variability of tasks for students in a special training course, one of the options of group discussion was used – the method of "brainstorming" as a common group way of problems-solving by generating new ideas by participants, which stimulates creative activity, creativity, enrichment of constructive experience, search and development of new, non-standard solutions, saving resources, time and energy of the team and its members.

Also, the brainstorming was carried out following the rules (unlimited number of ideas, lack of criticism and evaluative judgments, equality of participants) and contributed to the development of tolerance skills and group integration in a digital environment.

The training program included a list of tasks for brainstorming in the chat: "Specifics of management of vocational education in the digital educational space", "Basic tools for personal development of subjects of the educational process in distance learning", "The role of creativity in entrepreneurial activity vocational education", etc. Moving on, in addition to joint development of group work rules in the virtual learning environment, heads had the opportunity to expand understanding and understanding of the content and specific features of management in the digital educational space, conditions and ways of personal development of distance learning, as well as awareness of emotionally motivated orientation of management activities in the digital educational environment.

The inclusion of short interactive mini-lectures in group discussions has intensified the development of the heads' personal readiness of vocational education institutions to manage in the context of digitalization of the educational space by expanding psychological knowledge about the advantages and problems of the virtual educational environment, the peculiarities of the attitude of leaders to distance education, to managing a vocational education institution in a distance format, in distance education services and the peculiarities of their provision, for the personal readiness of the head of a vocational education institution for management in the context of digitalization of the educational space and its development, the features of the manifestation of its components: self-control in communication and general abilities for entrepreneurship, determining the orientation of the personality, self-efficacy, etc. (Bondarchuk et al., 2014).

Effective, in our opinion, in the conditions of a distance postgraduate education, is a modified method of group interaction as work in small groups – for example, group work to analyze the implementation of distance learning in the educational process from the point of view of various subjects – students, parents, teachers, administration, etc., when the participants, having united within the learning environment in mini-groups, discussed the advantages and disadvantages of distance education and developed proposals to improve the effectiveness of the implementation of these changes.

It was also useful to involve role-playing and business games in the process of training interaction in the form of online conferences, which contributed to modelling the system of social relations, reducing emotional stress due to the verbalization of the existing situation, solving problem situations by teaching the ability to see and analyze the problem from different points of view, the formation of real partnerships with others based on cooperation and correction of the difficulties of personal development of leaders.

The essence of the role-playing game consisted in the fact that heads in a situation of remote interaction temporarily "assumed" a certain social role and demonstrated such behavioural models that, in their opinion, correspond to this role. Participants in the role-playing game had the opportunity to make mistakes and learn from them without much risk, got the opportunity to find out what other listeners see and feel, what reactions they cause in others with their attitude and behaviour. Thus, the role-playing game provided an educational function, creating models of distance interaction of listeners in conditions of equality in a dialogical partnership and the like.

As part of our program, we used role play to improve the skills of effective communication and interpersonal interaction of students during management activities (Kazakova, 2020). At the same time, we took into account the possible limitations of this form of conduct and the shortcomings of the method itself: an excess of visual images, an increase in the proportion of emotional rather than rational judgments, a certain artificiality of the procedure, the unrealistic scenario of the game, frivolous attitude of the participants, etc. At the training, heads were offered the following role-playing game – “Online Meeting”. Among the participants, the leader and his/her three deputies were elected, who conditionally participated in the meeting, other members of the group acted as observers. Participants were invited to discuss the plan of work of the institution in the conditions of quarantine, analyze the difficulties connected with it and outline ways of increase of efficiency of rendering of distance educational services.

Besides, our program used business games as a method of finding solutions in a conditional problem situation related to the heads’ professional activities and as a method of active learning that contributes to the development of decision-making skills in the heads of vocational education institutions in non-standard situations, as well as a means of testing abilities to work out and improve existing organizational and managerial processes (Kredentser, 2011).

Thus, we have proposed a business game “Institution of vocational education: Yesterday, Today, Tomorrow”. The trainees were divided into three corresponding mini-groups, each of which was combined in a virtual learning environment using Viber messenger to develop common positions, and then the results were presented to the whole group, followed by their discussion.

The participants were offered the following instructions: 1) by creating a new group in the messenger, to jointly analyze the conditions of activity of vocational education institutions and the factors of ensuring their effective activity yesterday, today and in the future; 2) determine the basic requirements for the personality of the head who successfully implemented, carries out and will manage the institution under appropriate conditions. Thus, the heads had the opportunity to realize the importance and relevance of the development of the heads’ personal qualities, apply a set of knowledge gained on the defining characteristics of the head’s personality for the successful implementation of management, as well as the skills and abilities acquired for the development of personal readiness for management in modern conditions of distance learning.

In the training program, we used methods aimed at developing the ability to perceive, understand and constructively evaluate ourselves and other people. During training sessions with the help of exercises specially adapted to distance conditions, such as “However, you ...”, “Who am I? What am I?”, participants received verbal and non-verbal information about how other people perceive them, how these ideas coincide with their own, acquired the skills of deep reflection, semantic and evaluative interpretation of the object of perception.

In the program of the special course, we used exercises of a projective nature: drawing, analysis of managerial situations, etc. Projective methods as components of training work stimulated a thorough study of their resources in the heads of vocational education institutions, as the process of creating any creative product is based on such psychological functions as productive imagination, active perception, fantasy and symbolization. Therefore, we considered the projective image, first of all, as a projection of the head’s personality as a symbolic expression of his/her attitude to management in modern conditions, digitalization of the educational process, vocational education institutions, etc.

It should be noted that the use of projective techniques contributed to an overall positive attitude, which manifested itself in interest, involvement and spontaneity. For example, students, using a drawing, created a portrait of the head of a vocational education institution, capable of balanced risk or capable of innovations, and the like.

A striking example of the use of the incomplete sentences method was our modified exercise “Creative” (Kredentser, 2011), which contributed to the creative approach in the process of communication with colleagues in the implementation of digital educational technologies, encouraging themselves and others to generate creative ideas, when participants were invited to express in the chat as many creative ideas to solve the list of proposed situations in the digital educational environment.

Also, in the training program used for the situations analysis (a detailed analysis of the problem of professional situations). The application of this method allowed participants to more clearly articulate their difficulties in mastering new types of behaviour, realize their role in this situation and evaluate their actions. Heads had the opportunity to analyze and discuss situations they face or may face in the actual process of managing a vocational education institution. They evaluated, predicted, analysed different options for the consequences of the heads’ behaviour. In particular, the following situations were proposed:

- Your deputy expressed concern about the deteriorating mood, decreased motivation to teach in the teaching staff of the institution during quarantine restrictions. What are your actions?
- Within two to three months, not very positive reviews have been written on social networks about the specifics of organizing distance learning in the

institution you run. What are your actions?

The advantages of the situation analysis method include the development of the heads' skills of vocational education institutions for a comprehensive analysis of the actual problems of the activities of the institutions they manage, taking into account many factors (the development of skills of creative and critical thinking, making balanced, collegial decisions, the development of skills of cooperation and group interaction in the digital educational environment, etc).

The program of the special course included diagnostic methods that were used for self-diagnosis by participants, and to study the effectiveness of the program.

Applied exercises that contributed to the development of heads' personal readiness of vocational education institutions per our identified indicators were developed personally by the authors or modified following the purpose and objectives as well as the specific implementation of remote special course (Bandura, 1971; Bondarchuk, 2008; Frager and Fadiman, 2012; Karamushka, 2004; Kazakova, 2020; Kredentser, 2011; Mogilevkin, 2007; Pakhalyan, 2006).

To enhance awareness, deepen reflective analysis and consolidate a positive attitude towards oneself, confidence in one's effectiveness, constructive experience gained by participants in the process of the training process, the program includes individual tasks for independent work. Hence, heads were asked to analyze how the head's confidence in their effectiveness in the digital education space affects the quality of management activities in the institution in which they work; write an essay on the topic "The head of a vocational education institution is the leader in the implementation of distance education in the region"; develop a plan for the digitalization of the educational space, taking into account the specifics of the institution per year, while providing possible decision-making options; analyze their personal readiness as the head of a vocational education institution for management activities in the context of digitalization of the educational space and draw up an individual program for its development.

The program is designed for 30 hours (including 12 hours of classroom training and 18 hours of individual work) and was implemented in the format of a special course "Development of heads' personal readiness of vocational education institutions for management in the digitalization of education space" using the BigBlueButton platform (http://bbb.uem.edu.ua/).

The content of the program consisted of two training modules (Module 1. "The head's personal readiness of a vocational education institution for managerial activity in the conditions of digital educational space: essence and indicators"; and Module 2. "The development of head's personal readiness of a vocational education institution for managerial activity in the conditions of digital educational space"), which fully contributed to achieving the goal of the formative stage of the research.

Consequently, there is a need to disclose the content of the program for the development of heads' personal readiness of a vocational education institution for management activities in the digital education space following the selected modules.

Within the framework of the implementation of the first module "The head's personal readiness of a vocational education institution for managerial activity in the conditions of digital educational space: essence and indicators" the main forms of group work (group communication, discussions, mini-lectures, individual tasks, diagnostic other actions) were identified, which best help solve such issues:

- actualization of the needs of participants in improving the efficiency of management in the digitalization of educational space;
- systematization and deepening of the idea of professionally important head's personality traits of a vocational education institution, significant in the digital education space;
- development of heads' beliefs about their value, efficiency, controllability and managerial competence in professional life;
- improving understanding of the processes of self-regulation in complicated communicative situations in the digital education space.

Working in the virtual learning environment on the platform began with a discussion of organizational issues, namely defining the purpose and objectives of training, studying the expectations of participants, discussing the rules of group interaction, helping to adjust to constructive communication, increase group cohesion, reduce psychological discomfort remotely, etc. For this purpose, at the beginning of each meeting, using various forms of activity (self-presentations, icebreakers, voicing the actual well-being and psycho-emotional state, psycho-gymnastic exercises), which set participants to support a positive group atmosphere, providing opportunities for individual and group reflection.

This was achieved by using, for example, icebreaker exercises, when participants took turns continuing the phrase: "No one knows that I …". Whether performing a modification of the exercise "Who am I", during which heads recorded three items, and then presented the results in the form of a mini-presentation “Subordinates think I am … Students think I'm… In fact, I am…”. Or participation in a modified and adapted for the remote environment version of the game “The ball”, in which participants, passing the conditional ball in the chat to the next, continued the phrase: “I am an effective head of a vocational education institution because …”, “For me, it is important to have a team in the institution because …”, “If there are difficulties in the work, I am …”, etc. After each exercise, there was a discussion about the state of health, the current emotional state, which helped to strengthen the personal and group reflection of heads.

To exploring expectations, heads were asked to answer questions in general notes: “What are your expectations from the special course?”, “What questions are most relevant to you in the context of the topic of the special course?”.

Actualization of theoretical aspects of heads' personal readiness was carried out by including in the program content of a special course of mini-lectures and messages from the trainer with the subsequent group discussion and other practical tasks: “The purpose, objectives and structure of the special course”, “The role of entrepreneurship in the structure of heads' personal readiness of vocational education institutions for management activities in the context of digitalization of educational space”, “Personality orientation as an important head's professional quality in a digital educational environment”, etc.

To intensify the group discussion, we used the results of the method of incomplete sentences, which served as material for discussion in group discussions: “The digital educational environment of a vocational education institution is …”, “The head's personal qualities of a vocational education institution in the modern digital environment are…”, “Competitive strategies for managing a vocational education institution in the digital space are…”, “The most important aspects in the process of interaction with the team in the digital education space are…”, etc.

The answers were recorded in a chat, then highlighted on a slide in a virtual learning environment and discussed by all participants. In the course of the discussion, the facilitator received special encouragement from the answers, which emphasized the importance of personal qualities that are important in management in the digital education space.

Implementing the tasks of the first module, the program of the special course included “brainstorming” “Rules of the vocational education institution in the digital environment” with subsequent group discussion, when participants wrote in general notes all possible options to support psychologically comfortable digital space of the educational organization which they manage. It should be noted, that heads were very active and inspired to make proposals based on their experience, as well as finding non-standard, creative ideas for creating and maintaining a favourable digital environment.

In our opinion, the inclusion of the entrepreneurship development unit in the program contributed to the awareness of the heads of vocational education institutions of the need to develop entrepreneurial activity as a necessary professional quality of an educator in modern conditions of digitalization of educational space. This task was achieved by group discussions in chat and audio and video presentations “The main characteristics of the entrepreneurship of the head and staff of the educational organization”, the generalization and discussion in an interactive mini-lecture using a multimedia presentation “The essence and importance of entrepreneurship in the activities of heads and staff of vocational education institutions”.

In particular, increased interest and active involvement were caused by the implementation of a modified version of the exercise “Identification of innovation in the process of digitization of educational space” (work in small groups with further discussion) (Kredentser, 2011), during which participants were asked to develop a plan for innovative changes related to development digitization of the educational environment by items: 1) The purpose of innovative change; 2) Available resources for implementation; 3) Risks of implementation; 4) Plan for the implementation of innovative changes; 5) Demonstration of innovative personality traits.

Participants in small groups formulated the goal of the jointly chosen innovative change; analysed the existing and imagined opportunities for project implementation, as well as deterrents, restrictive and inhibitory circumstances that could potentially affect the success of implementation; developed a step-by-step plan for introducing innovative change; listed the necessary head' personality traits for the effective implementation of digital innovations in the educational process. In the end, audience member presented the results of the joint work of their group to the whole audience in a virtual learning environment, other participants acted as experts and wrote on the board of joint notes key, in their opinion, the position.

To increase self-confidence, develop confidence in the effectiveness of their actions, the ability to see in themselves and other positive qualities served exercise “Name differently”, which was performed individually with further discussion in the group. At the first stage of the exercise, heads were asked to make a list of 10 own qualities that do not like themselves.

The next step was to find situations where this quality would have the opposite meaning. For example, noting that the head is lazy, the phrase continues: "but I save resources".

The final stage of work on the program of this module contained tasks for independent work: performance of individual exercise "Creation of "flower" of own entrepreneurship", modified according to the purpose of a special course and adapted to conditions of distance postgraduate education (Krylov, 2000). Each participant of the program was asked to draw a flower, like a daisy, and on each petal to write down those characteristics of entrepreneurship of the head of a vocational education institution, which, in his opinion, are important in the digitalization of educational space, which served to build a personal profile of entrepreneurship. Then, if desired, participants in the learning environment presented the results, there were a discussion and feedback.

The results of processing the above methods of the first module were used in the process of working on the second module of the program "The development of the heads' personal readiness of a vocational education institution for managerial activity in the conditions of digital educational space", aimed at improving the personal qualities of heads in the field of vocational education, important in the context of improving management following the requirements of today's digital educational environment by solving the following tasks:

- improving skills of effective interaction in a virtual learning environment, creating a favourable environment by establishing positive feedback;
- systematization and deepening of perceptions about the role of entrepreneurship in the management of vocational education, the possibility of using a creative approach in solving difficult life and professional situations;
- expanding the repertoire of constructive management actions through the use of flexible competitive strategies in the context of digitalization of educational space;
- development of skills to receive and provide feedback and support in difficult professional management situations.

To consolidate and develop constructive personal innovations of the program participants, within the framework of this module the use of various interactive training forms (group discussion, work in small groups, role-play, exercises, etc.) was envisaged.

Consequently, the search for internal resources to overcome complex management situations, increase the variability of effective self-regulatory strategies, as well as the development of skills to adequately express their emotional states, and thus the development of a reflective attitude towards others, helped the method of incomplete sentences: "I am inspired by...", "I am happy...", "I am glad...", "I soothing...", "I am worried about...", "I am concerned...", "I am sad from...", etc.

The training exercise in our modification "How entrepreneurship manifests itself in the work of the head of a vocational education institution" (Kredentser, 2011) aimed to deepen the understanding and importance of the main characteristics of entrepreneurship of the education head, such as following: persistent motivation and persistence in achieving goals, activity, initiative, independence and innovation in the personal, social and professional aspects of life. So, the participants in the general chat wrote or in an audio or video address talked about the actions of an enterprising person to demonstrate these qualities in life, and suggested ways to develop them.

To develop a reflective position, self-understanding, conscious modelling and design of management activities of heads of vocational education institutions used a modified exercise "Technique of personality development" (Frager and Fadiman, 2012), in the process of which the following instructions were given: 1) split the sheet in half, write on the left the personality traits they would like to get rid of (preferably at least five), on the right write the opposite trait they would like to get; 2) identify the traits that participants would like to acquire in the first place, analyze what can be done immediately to get closer to the ideal state, how to behave.

To improve the ability to creatively use available resources in the process of interaction in the digital education space following the objectives of the second module was the inclusion in the program of a special course of business and role-playing games "Online Meeting", the essence of which is given above.

Analytical work in small groups on the joint project "Portrait of a successful head of a vocational education institution in the digital educational space" (Bondarchuk, 2008) helped to summarize the experience of significant characteristics of the personality of the head in the digital educational space, skills to tolerantly express their thoughts and approach to solving problems, maintaining partnerships, friendly relations, opportunities to show their talents and creativity. To do this, rooms were created for group work in a virtual learning environment, where participants had the opportunity to discuss and identify common key positions, recording and editing them in a common chat room, and then presented the results of their projects to the whole group and discussed the results.

Completing the special course program to gain a positive experience from participating in the training and creating a situation of success, a modified exercise “Wish Basket” (Bondarchuk, 2008) was proposed, which was implemented in two stages. At the first stage, each participant in the chat prescribed wishes to others, putting them in an imaginary basket. In the second stage, each head chose a number from 1 to 23 (according to the number of participants), and the trainer read inspiring phrases of the following content:

- Life is preparing something extremely pleasant for you!
- Love yourself as you are!
- Make yourself a gift, you deserve it!
- You will definitely be lucky soon!
- You are unique, just believe in it!
- You are able to achieve much more!
- You will definitely be lucky! etc.

At the same time, the generalization of the gained experience, conscious living of one’s personal achievements in the training process, isolation and transfer to real managerial situations of key skills of interaction with subjects of educational process in digital space was facilitated by group discussions to determine the most vivid impressions of the training, the main conclusion of the program; questionnaire to provide feedback to the trainer on the quality of content, level of organization and usefulness in practice.

4.3 The Results of the Analysis of the Effectiveness of the Program Implementation

The developed program for the development of heads’ personal readiness of vocational education institutions to manage in the context of digitalization of educational space was based on a combination of educational, training and developmental aspects, observance of the basic rules of group work, carrying out of rituals at the beginning and the end of each employment, verbalized reflection that created favourable conditions for the development of aspects of the person to a context of the researched problem.

Approbation of this program was carried out during 2020 based on the Central Institute of Postgraduate Education of the University of Educational Management in the form of a special course. The program of the special course covered 47 heads of vocational education institutions from different regions of Ukraine, of which 23 people formed an experimental group and 24 – a control group. The homogeneity of the experimental and control groups according to the initial data on the development of personal readiness and socio-demographic characteristics was ensured.

In the experimental group, the implementation of the program of heads’ personal readiness of vocational education institutions for management activities in terms of digitalization of educational space was carried out holistically, systematically, under psychological conditions, principles provided by certain methods, techniques and techniques of training. Forming experiment ended control testing.

In the control group, classes were conducted under the traditional curriculum of heads’ professional development of vocational education institutions, with only two diagnostic sections before and after the formative experiment.

Statistical processing of the results of approbation of the program “The development of heads’ personal readiness of vocational education institutions to management in the digitalization of educational space” was carried out according to the same methods as at the ascertaining stage of empirical research using SPSS software package, version 17.0 for Windows.

Analysis of the results of the implementation of the program for the development of psychological readiness of heads of vocational education institutions for management activities in the context of digitalization has shown its effectiveness in developing the heads’ personal readiness in this category (table 7).

So, the criterion χ^2 revealed that the participants of the experimental group between the results of the first and second sections were recorded statistically significant differences in the levels of heads’ personal readiness for management in terms of digitalization of educational space compared with participants in the control group ($p < 0.05$).

Also, among the participants of the experimental group between the results of the first and second sections on the G-criterion of signs were recorded statistically significant differences in the levels of personal readiness: an increase in the number of subjects with a high level of development from 20.8% to 54.1%, and a decrease the number of respondents with a low level from 16.7% to 4.2% ($p < 0.01$).

The participants of the control group did not show such positive dynamics in the indicators of readiness. So, as can be seen from table 7, the participants of the control group according to the results of the first and second sections were recorded statically insignificant differences in the levels of personal readiness. In particular, the number of surveyed heads with a low level of 16.0% to 8.0% decreased, but these differences are

Table 7: Quantitative indicators of levels of heads' personal readiness of vocational education institutions before and post the formatting experiment (* – differences are statistically significant at the level $p < 0.01$).

Levels of personal readiness	**Groups (number of respondents, in %)**			
	before the formatting experiment (1st cut)		**post the formatting experiment (2nd cut)**	
	experimental group	**control group**	**experimental group**	**control group**
Low	16.0	16.7	8.0	4.2*
Average	60.0	62.5	68.0	41.7*
High	24.0	20.8	24.0	54.1*

not statically significant.

It is noteworthy that the leaders – members of the experimental group after the formative experiment have changed the severity of the focus on the case compared with the participants of the control group (figure 2).

Figure 2 shows that the level of heads of the experimental group focus on the case is higher than the heads of the control group ($p < 0.05$).

Besides, along with the growth of entrepreneurial skills, social creativity, etc., according to the participants in the final questionnaire, the ability to better understand the qualities of education heads, important in the context of digitalization of educational space; positive attitude towards other people.

Indeed, heads, who participated in the program of personal readiness for management in the digitalization of educational space, had a pronounced ability to a more positive vision of others, greater awareness of the peculiarities of interaction in the digital educational environment compared with the control group.

The effectiveness of the program for the development of heads' personal readiness for management in the digitalization of the educational space is also evidenced by the results of the generalization of the feedback questionnaire conducted at the end of the special course. Specifically, 91.7% of respondents in the experimental group rated the level of their effectiveness due to participation in the program on theoretical and practical achievements as high, and 8.3% – as average.

Responding to the questionnaire, the respondents said that participation in the program helped them expand their theoretical knowledge about the development of personal readiness as a professionally important quality necessary for successful digitalization of educational space in the institution, to a better understanding of themselves, developed skills of self-control and constructive communication.

In response to questions about the establishment of successful interpersonal interactions in the digital learning environment in the experimental group, 95.8% of respondents noted its high level, and 4.2% – medium.

All respondents in the feedback questionnaire unanimously stated that they plan to use in their professional activities the knowledge gained through participation in the program of development of their personal readiness to digitize the educational space in the future.

So, during the approbation in the conditions of distance postgraduate education, the efficiency of the program of development of heads' personal readiness of vocational education institutions to managerial activity in the system of digital educational space is confirmed.

5 CONCLUSIONS

The article substantiates the content and components of heads' personal readiness of vocational education institutions (entrepreneurship, self-efficacy, focus and constructive communication, active-positive type of attitude towards other people, and social creativity), important for management in the digitalization of educational space.

The results of the empirical research revealed an insufficient level of both indicators of heads' personal readiness of vocational education institutions to manage in the context of digitalization of the educational process, and the level of their readiness in general. Ascertained difficulties in the manifestations of entrepreneurial activity, in assessing their effectiveness, the predominance of egocentric orientation, differentiated attitude to others depending on subjective, situational, useful factors, limiting the focus on creating a creative digital educational environment in a large number of subjects.

The specific features of distance postgraduate education in the context of changes in the field of education in recent years are highlighted (combination of synchronous and asynchronous interaction in the virtual learning space, the presence of motivating factors to unite participants in joint distance activities, the possibility of using interactive forms of distance interaction, the need to develop information and communication competence), and also the possibilities of development of personal readiness for management in

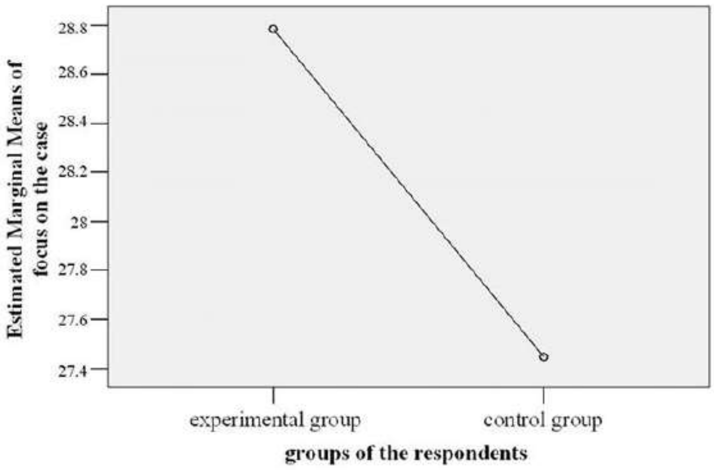

Figure 2: Peculiarities of the expression of focus on the case in the participants of the experimental and control groups of heads of vocational education institutions after the formative experiment ($p < 0.05$).

the conditions of digitalization of educational space through distance postgraduate education.

The program of development of heads' personal readiness of vocational education institutions to managerial activity in the system of digital educational space is developed and realized in the conditions of distance postgraduate education. The content of the program consisted of two training modules and was designed for 30 hours (1 ECTS credit) using the BigBlueButton platform.

The principles (professional development of heads of vocational education institutions, focus on self-knowledge and self-development of the individual, the use of active group teaching methods, creative activity, partnership) and psychological conditions (creating a special social environment, an atmosphere of emotional comfort and creative freedom, mutual support in the group, trust, respect, activation of adequate self-perception through reflective analysis) for the development of heads' personal readiness of vocational education institutions for management activities in the digital educational environment in terms of distance postgraduate education are substantiated.

The effectiveness of the author's program on the development of heads' personal readiness of vocational education institutions for managerial activity in the conditions of digitalization of educational space in the conditions of distance postgraduate education is proved. This is evidenced, in particular, by a statistically significant increase in levels of heads' personal readiness, as well as the positive dynamics of its development in all components of the participants of the experimental group in contrast to the control.

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Creativity of Foreign Languages Teachers in Ukrainian Higher Education Institutions: Empirical Data

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Keywords: Creativity, Foreign Languages Teacher, Creative Components, Value Component, Cognitive Component, Behavioural Component, Individual Psychological Factors, Organizational and Professional Factors.

Abstract: The study highlights the problem of creativity of foreign languages teachers of higher education as a powerful resource for self-realization and the development of the personality of higher education student. The research aims at describing the teachers' creativity as their ability to creative non-standard thinking, to effectively solve complex problems of both professional activity and their own lives. The article highlighted the results of empirical research of value, cognitive and behavioural components and individual-psychological and organizational-professional factors of creativity of foreign language teachers. According to the results of ANOVA, there were established statistically significant differences in the manifestations of creativity of foreign language teachers depending on their gender, age and organizational and professional characteristics. We offer the structure of the program of the development of creativity of the foreign languages teacher directed on the development of value, cognitive and behavioural components and individual-psychological and organizational-professional factors.

1 INTRODUCTION

At the age of innovative changes, unpredictable and ever-changing life demands the evolutionary transformations in all fields, including education. According to Kozbelt et al. (Kozbelt et al., 2010), these changes are impossible without the development of creativity. Since this development takes point from education, to form the foreign languages teacher's creative potential has becoming an urgent request. Moreover, the education base is creativity due to Guilford (Guilford, 1967), which expands the teacher's worldview; makes them to solve serious problems; promotes personal development; diversifies life; strives to self-realization and self-actualization.

The World Economic Forum in Davos at 2016 predicted that creativity in 2020 would be one of the three most essential skills that employers will value in their employees, along with critical thinking and comprehensive problem-solving. This forces higher education institutions to form an institutional environment, a creative teaching community capable of developing creativity, creative thinking, and involving students in the production of creative knowledge at all levels (Council of the European Union, 2007).

Increasing creativity in the educational process always begins with the education of teachers (Rinkevich, 2011), the formation of their competencies, which depends on motivation, competence content of the educational process and the competence of research and teaching staff and regulated by the Law of Ukraine "On Higher Education", Standards and Recommendations on quality assurance in the European Higher Education Area, Tuning Educational Structures in Europe (González and Wagenaar, 2008) and other normative legal acts, administrative documents which are in the field of responsibility of higher education institutions in the context of their autonomy.

In changing real-time conditions, teachers of higher education institutions by the requirements of international institutions to form general and special competencies of graduates (González and Wagenaar, 2008; Bakum and Morozova, 2015; Kazhan et al., 2020) should demonstrate a high level of effective development and implementation of innovative educational technologies, forms, methods and techniques

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in the organization and content of the educational process (Kulbashna, 2014; Savchenko et al., 2018). Teachers have to not only be creative and productive in any reformations but also: interact effectively in society; adequately respond to challenges; and activate their creative potentials. Thus, a modern graduate is ready to perform novel unexpected professional tasks that exceed knowledge and experience and require non-standard creative solutions from him or her.

Teachers have a pivotal role to play in creating a quality experience for students and providing conditions for the acquisition of new knowledge, competencies and skills (Smidt, 2015). And it is impossible to do without critical and creative thinking (Vlasenko et al., 2020), highly developed imagination, aesthetic worldview, and openness to new life and professional experience, flexibility, originality and so on.

Hence, to form a creative personality, it is relevant to: create an appropriate creative environment, promote the development of a high level of creative abilities, creative potential and be inclined to creative activity, etc. "High educational institution has always been a place of creativity but in the XXI century. There are much higher requirements for educational institutions - to become a creative teaching community, where students participate in the production of creative knowledge at all levels" (Korniyenko, 2021).

Creativity is essential both in the theoretical and practical activities of higher education teachers. After all, as Zhuravlova and Filonenko (Zhuravlova and Filonenko, 2012) point out, a creative teacher perceives problems from a different angle, does not turn into a stereotypical solution to the problem, but solves it in an intriguing new way. The creative teacher personality is characterized by originality, tolerance to uncertainty, openness to new informative and thorough knowledge, diligence and self-demands. These allow the teacher to create new products and implement them in professional activities.

Hence, creative teaching is important in all fields of education, as a creative foreign languages teacher of higher education improves and develops students' creativity, their perception about creativity, and assists with a successful way into further life.

But the main outcome of creative teaching is that creative foreign languages teachers of higher education institutions teach their student how to upgrade their creative ideas, beliefs and behaviour (Morris, 2006). In addition, creative teaching is natural part of foreign languages teachers of higher education institutions. Accordingly, foreign languages teachers of higher education institutions have three advantages in creative teaching, i.e. all languages are naturally creative; languages classes are unlimited in time of topics, and the visualization of real life situations through different tasks in the classes (Stepanek, 2015).

Creativity of foreign languages teachers of higher education institutions acquires special meaning, as it is a powerful resource for the development of student's personality of higher education institutions (Moskaliova, 2014), promotes the development of constructive, critical thinking and professional competence.

Therefore, the teacher's creativity, his ability to creative non-standard thinking, the ability to effectively solve complex problems of both professional activity and his own life are of particular importance (Balakhtar, 2019b,c). Consequently, the present study has aimed to explore the peculiarities of creativity of foreign languages teachers of higher education institutions.

2 LITERATURE REVIEW

Around the world, there are many scholars, scientists and theorists who have made a great contribution to research about creativity. Creativity is seen by many researchers in terms of novelty, originality, productivity, problem-solving ability, the ability to be reflexive and risky (Amabile, 2001; Tanggaard, 2011). To identify the concept of creativity, it is better to differentiate the terms of creative potential, creative actualization and creative talent (Barbot and Lubart, 2012; Besançon et al., 2013).

Walberg (Walberg, 1988) stated that the creative potential is hidden skill to generate the effective original work which is a part of personal's capital. Creative potential is a mixture of resources becoming functional with aspects of motivation, cognition and personality (Sternberg, 2020; Sternberg and Lubart, 1995). The personal's achievement, which is creative, considers as creative actualization. Therefore, creative talent is an ability to produce creative work (Besançon et al., 2013).

Among modern Ukrainian researchers, a significant groundwork in the development of the concept of creativity as a deep, initial and completely "natural" personality traits, mechanisms of creative thinking, the creative potential was made by Maksymenko (Maksymenko, 2013), Moliako (Moliako, 2007) and others.

Particular attention in the context of the problem under study deserves the work of scientists devoted to the study of the psychological characteristics of the creative potential of heads of general educational institutions (Bondarchuk and Pinchuk, 2015) as a factor in constructive solutions to managerial problems

(Moskaliova, 2014), the formation of communicative competence of leaders of educational organizations (Briuhovetska, 2010), the formation of a creative style of activity, knowledge and development of intellectual and creative abilities (Sologub, 2005, p. 4-5) and others.

Hence, creative potential specifies the mixture of individual and contextual resources becoming effective in a creative work within motivation, cognition and personality factors (Sternberg and Lubart, 1995). Importantly, Sternberg and Lubart (Sternberg and Lubart, 1995) determine creativity is more than a combination of an individual's resources.

Scholars consider on the three points: creativity is impossible if there are some thresholds for some components (for instance, knowledge) even when other components are high; some compensation prevails when one component is more powerful than the other one and confront it (e.g. knowledge versus motivation); creativity is in process when all the categories are present and active (Sternberg, 2020).

The system of knowledge, skills and abilities is dominant in the activity of teachers. It is vital to develop the mental qualities, types and forms of thinking (including critical) depending on the specifics of professional activity. According to Makarenko (Makarenko, 2017), the cognitive component relies on the intellectual sphere and reflects "awareness and knowledge of reality about the profession, possession of a set of theoretical and practical knowledge on which praxeological foundations of professional activity and practical thinking, and ways of acquiring knowledge are based".

Knowledge serves as a "special form of spiritual assimilation of the results of cognition, the process of reflecting activities, which is characterized by awareness of their truth". Assimilation of knowledge is characterized by purposefulness, systematicity, consistency, logic and meaningfulness. Knowledge determines the teacher's attitude to morality, work, value system, activity and reality in general.

The recognition of the values has a significant role as certain beliefs remain a central place in the individual belief system and serve as guiding principles of life. Value orientations are a mandatory component in the professional teacher's activity, display the life experience, life goals of the individual, and indicate what is most in demand for him/her and has a personal meaning. After all, the internal acceptance of personally unhesitating senses is an imminent condition for the personal values formation (Honcharenko, 1997, p. 137). As for personal values, it is, as Radul (Radul, 2019) notes, aware and accepted by the individual general meanings of his life.

A teacher of higher education must have universal (life, man, tolerant, society, happiness, justice, etc.), national (national idea, native language, the language of other peoples, traditions, customs, national symbols, folklore, etc.), civil (democratic) rights and responsibilities, tolerance for dissenters, respect for the culture and national traditions of other peoples, religious tolerance, etc.), family (values of family life: respect, love, mutual aid, the harmony of relationships, etc.) and personal (education, self-realization, health, life wisdom, etc.) values (Yanitskiy, 2000, p. 6).

It is worth noting that teachers' ideas about the system of values, the hierarchy of its beliefs are relevant today. Thus, Rokeach (Rokeach, 1973) describes values as a firm belief that a particular behaviour or ultimate goal of existence has potential significance from his point of view, and may differ from the opposite or opposite behaviour or ultimate goal of existence. Thus, values act as the standards or the criteria regulating as installations, so and actions, comparisons, estimations. In other words, they legitimize the individual and his environment (Farcane et al., 2019).

Creativity is the foremost quality of a person of the XXI century and is of paramount importance in the formation of higher education institutions teachers' professional and methodological competence, in general, and teachers of foreign languages in particular. It "... is a human activity, as a result of which new material and spiritual values of social significance are created. Creativity, being the work result and individual's efforts, at the same time, always has a social character" (Rokeach, 1973). Creativity is a process that contributes to the creation of new. Creativity is considered as a potential, an inner person resource, which is a relatively stable characteristic of the individual and provides the ability to abandon stereotypical ways of thinking, acquire the ability to identify new ways of solving problems or new forms of expression (Bondarchuk and Pinchuk, 2015; Dyachenko and Kandybovich, 1998).

According to Hamza and Griffith (Hamza and Griffith, 2006), teachers should be "accessible, friendly, knowledgeable, interesting, caring, leaders, insightful, imaginative, and able to manage conflicts, minimize disruptions and create innovative classes in the classroom".

According to Saprykina (Saprykina, 2013), the components of creativity of the teacher's personality are motivation, psychological and pedagogical knowledge, general erudition, pedagogical intuition, highly developed intellect, high level of universal culture, and professional mastery of various methods of teaching and education. The researcher notes that a creative teacher is independent, self-reliant and persistent, has high intellectual development, sense of humour, lively mind and acting character, and is able to show flexibility in their views.

Achieving the formation of the components of creativity is complicated by the specific features of the pedagogical activities of higher education institutions teachers, which are characterized by: "a special kind of subjective professional interaction; multifunctionality and increased degree of professional responsibility; the need for continuous self-improvement in teaching and research; the ambiguity of criteria for assessing the effectiveness of scientific and pedagogical activities; increased social requirements for professional and personal qualities of the teacher, etc" (Bondarchuk and Pinchuk, 2020).

The creativity of a higher education institutions teacher, including a teacher of foreign languages, is an integral part of personal development, which interacts with creative socio-cultural relationships, intellectual baggage of knowledge and spiritual values, experience, skills and abilities between all subjects of socio-pedagogical activities, which necessarily contributes to self-realization, adaptation, socialization and self-affirmation of the higher education teacher (Petryshyn, 2014).

A foreign language teacher may implement various activities in the process of teaching foreign languages, which contribute to both the development of thinking skills and pronunciation of students: "creation of associations, analysis of cause-and-effect relations, decision-making, problem-solving, creative thinking" (Puchta and Williams, 2011). The higher education teacher may carry out the creative teaching in two ways: a) creatively teach and present educational material; b) teach for encouraging the development of creativity in the personality of each student.

Creative teaching involves the use of figurative approaches in the construction of the educational process to make teaching more entertaining, exciting and productive. Teaching for creativity is challenging but enjoyable, fascinating and efficient. In this case, the teacher spends more time on: planning the lesson; creating and developing ideas; evaluating the effectiveness of selected tools and teaching methods; improvising, using interactive teaching methods; taking risks every day; and assuming that the methods and techniques he/she uses do not always work. Creative teachers are always ready to experiment, realizing the need for teaching experience (Guilford, 1959), "extremely responsible for the quality of teaching, always energetic, caring about the subjects and creative" (Volobuieva, 2011).

Buzovska (Buzovska, 2014) considers the pedagogical creativity of a foreign language teacher to be a decisive factor in the development of creativity in professional activity on the way to the top of pedagogical skills. She estimates the components are creative thinking, production and generation of new original ideas and approaches, problem-solving unconventionally.

According to Morozov (Morozov, 2004), pedagogical creativity consists of communicative and didactic components. At the same time, the basis of communicative creativity is dialogue and improvisation, and didactic creativity is receptivity to intellectual values and the ability to innovate.

According to Sidorenko (Sidorenko, 2001), the creativity of a foreign language teacher has contradictions in problematic situations or creative tasks, as well as objective (social and material) and subjective (purpose, knowledge, skills, motivation, etc.) prerequisites for development and realization of creativity in the process of teaching foreign languages, the presence of novelty and originality in views on the process and outcome of teaching.

Moreover, the teacher may indirectly influence the modelling of value orientations of higher education institutions students, their behaviour and actions during teaching foreign languages. The peculiarity of a foreign language teacher professional values is due to his/her teaching a language that, "regardless of ethnicity and genealogy is one of the most valuable works of humanity as a civilized community, a reflection of the mentality of the natives, the phenomenon of identification and culture" (Mamchur, 2016).

Besides, scientists believe that such components like his/her inner potential, social and professional experience, psychological, pedagogical and subject knowledge, the ability to create new ideas, skills and capabilities of the future specialist shape the creativity of a foreign language teacher (Marchiy, 2008); creative thinking (improvisation, fictional spontaneous situations, real experience, existing knowledge in a new form, etc.) (Fisher, 2005; Oliver, 2013; Sawyer, 2011); intelligence, knowledge, thinking skills, personality, motivation and environment (Sternberg and Lubart, 1993), etc.

It is also worth noting that the pedagogical creativity of a foreign language teacher is realized during working and is manifested in the desire to improve the professional level and achieve pedagogical skills. Thus, if teaching a foreign language is fascinating and exciting, then, as Starbuck (Starbuck, 2006) says, it is creative teaching with a creative foreign language teacher.

The professional development, high level of motivation, openness, high sense of security, propensity for new and flexible actions, goal-oriented teaching are those means that better characterize the creative personality of a foreign language teacher. At the same time, it is also vital to have remarkable intelligence, diligence, energy, intuition and self-confidence (Tavarez DaCosta, 2019).

The indicators of creativity of a foreign language teacher include:

- a developed memory;
- the ability to concentrate;
- to clearly and logically formulate their ideas, tasks;
- to acquire skills of analysis of complex situations and problems, using them in terms familiar to the interlocutor;
- to have a high intensity of generating ideas, carefully filtering;
- the capability to synthesize the general picture;
- to be creative;
- to critically evaluate the results of research, especially their own;
- to develop a broad scientific worldview;
- to get acquainted with the scientific and practical results of related fields;
- to strive for high culture, etc.

Creativity promotes self-development, adaptive response to changing societal conditions and allows producing new ideas using the creative abilities of teachers, their intellectual experience, and openness to experience. We suppose it necessary not only to consider the essence and structure of creativity but also to explore factors that contribute to the development of the creative potential of foreign language teachers.

Thus, among the factors that contribute to the development of the creative potential of foreign language teachers, Bretsko and Marushka (Bretsko and Marushka, 2018) identify: the motivational sphere, the desire for self-development, improvement of personal professional skills and abilities; taking into account individual personality traits; awareness of the significance of the humanistic value of the creative individuality of the individual; specific organization of training of future foreign language teachers; development of abilities of future specialists to the analysis, awareness of results of own professional activity; mastering the knowledge of creative potential, knowledge and understanding of the peculiarities of its development, combine and use in pedagogical activities in the study.

Besides, the researchers have found that following properties characterize the creative personality of a foreign language teacher, as: flexibility, spontaneity, creative thinking, imagination, originality, creative attitude to the profession, demanding the results of their work, achieving the defined goal of creative activity and effective solutions to problem situations, the ability to deviate from stereotypes and inertia of thinking in teaching, create creative products; need and readiness for creative and professional self-realization; non-standard attitude to oneself, the world around, to any life situations and phenomena.

The psychological factors of development of professional creativity of a teacher of foreign languages singled out by Hotsulyak (Hotsulyak, 2008) deserve special attention in the context of our research. These include the motivational readiness of the teacher to work systematically to improve the level of methodological skills; ability to critically analyze one's own professional activity, which makes it possible to identify characteristic psychological barriers and choose "developing" strategies for their prevention and overcoming; self-analysis of the formed system of methodical and professional knowledge, skills, abilities and search of new means and ways of teaching a foreign language; mastering by the teacher of innovative interactive methods, forms and methods of solving specific tasks of teaching a foreign language with the observance of the appropriate psychological continuity of the stages of mastering the methods of solving methodological and pedagogical problems.

Thus, taking into account the above and taking into account the definitions of creativity in the works of scientists, we interpret the creativity of a foreign language teacher as personal property, an inner resource that allows creative and innovative activities aimed at producing and generating original (non-trivial) foreign ideas and approaches. languages, effective solution of tasks in a non-traditional way, constructive non-standard and critical thinking, the desire to improve their own experience, professional abilities on the path to self-realization and the formation of creative personality of students in foreign languages, using interactive teaching methods involving innovative technologies.

Components of creativity of a foreign teacher are a cognitive component (system of general and appropriate knowledge about creativity, features of creative potential, understanding and understanding of methods of teaching foreign languages based on creative technologies, production of non-trivial ideas, critical thinking), value (set of values, needs and motives), which promote and accompany creative and innovative activities) and behavioural (effectiveness in making non-standard decisions, creating creative products, the ability to self-organize creative work, etc.) components. The individual psychological (perfectionism, self-esteem, etc.) and organizational-professional (creative environment, professional workload, communication, compression, etc.) factors promote the development of the creative potential of foreign language teachers is promoted.

In addition, contrary to common beliefs, creativity is not only for exceptional people but it is a developmental thing for all people (Kaufman and Sternberg, 2007; Sternberg and Williams, 1996).

3 METHODOLOGY AND RESEARCH PROCEDURE

Presently, there are many different technologies to measure the personality's creativity and creative potential.

To study the components of creativity of foreign language teachers, we used: M. Rokeach's method "Value orientations" (Rokeach, 1968), K. Ryff's questionnaire "Scales of psychological wellbeing" (Ryff, 1989), test "Diagnosis of the creative potential and creativity" (Rogov, 1999), scale "Aspiration to be an independent person" test "Creativity" (Nikiforov et al., 2003), V. Boyko's method "Diagnosis of communicative tolerance" (Boyko, 1998), method of reflexivity by A. Karpov (Karpov, 2003), method "Scale of self-efficacy" by R. Schwarzer and M. Jerusalem (Topolov, 2011), O. Filatova's methodology "Passive Perfectionism Scale" (Filatova, 2016), S. Budassi's "Personality Self-Assessment Method" (Chudnovskiy, 2006), P. Spector and S. Jex's "Professional Stress Scales" (Topolov, 2011), P. Spector and S. Jex's "Professional Workload Scales" (Topolov, 2011), P. Spector and S. Fox's (in the adaptation by E. Topolov) method "Factual Autonomy Scale (FAS)" (Topolov, 2011), constructive resistance scale (Topolov, 2011), method of incomplete sentences in author's modification.

The research was conducted among the foreign languages teachers of higher education institutions. The total size is 208 foreign languages teachers of higher education from different regions of Ukraine (Chernivtsi – 53% of respondents and Kyiv – 47% respectively). The test includes eight indicators: curiosity, self-belief, resilience and persuasiveness, ambition, auditory memory, visual memory, the desire to be an independent person, the ability to think abstractly and, the last one, the ability to focus on business. Accordingly, we identified the levels of creativity:

- low – creative potential is limited, there is a lack of faith in own strength, self-underestimation;
- average – indicates the ability to improve the creative potential by destroying the fear of failure and public condemnation;
- high – creative potential is enough high and broadens the creative opportunities.

The respondents were grouped by:

- gender (male – 39.4% and female – 60.6%);
- age – 1 - up to 30 years (22.1%), 2 – 30-40 years (28.8%), 3 – 40-50 years (26.9%) and 4 – over 50 years (22.1%).

We processed the data and made the presentation of results with the statistical software package SPSS 21.0.

4 ANALYSIS OF RESEARCH RESULTS

First of all, we were interested in the system of general and special knowledge of foreign language teachers about the essence of creativity, understanding and awareness of the features of creative potential, the specifics of creativity in the professional activities of higher education institutions, their ability to reflect and more.

After all, there is a growing need for people with non-standard thinking, ready to show a creative approach to solving various problems, able to adapt to rapidly changing socio-economic conditions, competitive in the European labour market. Creativity is a formidable factor in the development of personality, its ability to abandon stereotypical ways of thinking, to bring something new to the experience (Barron, 1969), "the ability to reflect the individual's ability to create new concepts and develop new skills, i.e. the ability to create" (Morozov and Chernilevskiy, 2004).

The cognitive component of teachers' creativity in foreign language teaching should be based on mental processes and actions, the basis of which is the understanding and use of this phenomenon in speech (Hodovanets and Lehan, 2016).

According to Kolesnikova and Dolgina (Kolesnikova and Dolgina, 2001), in the acquisition of cognition the following components play a significant role: the performance of speech actions according to rules (level of rules); awareness and understanding of meanings of lexical units (level of meanings); peculiarities of formulation of utterances, their structure (level of speech activity); awareness of utterance function (requests, advice, objections, etc.) (social level); awareness of the conformity of the reported information to the cultural norms of native speakers (cultural level); awareness of higher education students of the peculiarities of education (techniques, methods, tools, etc.); evaluation of their effectiveness, and also self-assessments of the level of language learning (students' cognitive style of work).

Teaching foreign languages involves not only mastering the actual linguistic knowledge but also the translation of knowledge about the world. After all, mastering a foreign language, we "learn the image of the world inherent in the relevant people, a vision of the world through the prism of national culture, one of the most important components of which is language".

According to Leontyev (Leontyev, 2017), the main task of mastering a foreign language is to "learn to orientate as a native speaker does". This forces teachers to ensure the appropriate context in the classroom by regularly creating tasks following new modern needs and challenges (problem situations, active communication, active participation in dialogues, seminars, workshops, conferences, creative tasks, projects, etc.), initiative and the development of interactive teaching skills.

The study of the features of creativity of foreign language teachers in higher education institutions was conducted by the indicators and criteria of value, cognitive and behavioural indicators of the components presented in the author's model. First of all, we were interested in the value attitude of foreign language teachers to the constructive transformation of reality.

After all, the study of foreign languages involves not only direct modelling of the person's value behaviour and actions but also (Topolov, 2011):

- involves students in socio-cultural relations;
- promotes a person's ability to be tolerant of another nationalities and cultures;
- pays attention to their own culture.

According to the results of empirical research, we revealed an insufficient level of development of value, cognitive and behavioural indicators of the components of creativity of a foreign language teacher.

Thus, table 1 shows that the vast majority of researchers are characterized by a low level of need for interesting (creative) classes (76%), which probably leads to a lack of motivation to create innovative methods and techniques (75.5%), designed to improve the quality of activities, its effectiveness. It is worth remembering that needs are the primary source of motivation to implement interesting (creative) activities.

Besides, motivation is related to attitude, in particular, a high level of positive attitude to the formation and development of creative abilities was found in 75.5%) researched teachers.

However, the value of creativity in the transformation of reality characterizes about half of the respondents (49%), and the desire for self-development (27.9%), freedom (individual independence) (38.5%) – in about a third of respondents. In our opinion, this may cause problems in the implementation of creative thinking and the development of abilities, motivating, directing and regulating functions in teaching foreign languages to students.

Analysis of the value component of the creativity of foreign language teachers shows a certain inconsistency of their values with the purpose and objectives of professional activity, however, without a value approach, "neither activity nor human life as a being with different needs, interests and goals is impossible" (Tugarinov, 1988, p. 256).

Therefore, in our opinion, special attention should be paid to promoting the development of motivation, values, the interest of teachers in creative teaching of foreign languages, reducing the influence of various demotivators of their professional activities (low wages, lack of opportunities to improve skills, develop their creativity, develop and implement innovations, etc.).

Table 2 shows an insufficient level of the cognitive component indicators of creativity of foreign language teachers. Thus, most of the respondents are characterized by low (clear ideas about creativity and features of foreign language teaching) (77.9%), the ability to produce non-trivial ideas (original) (69.2%) ability to understand and accept the individuality of another (46.2%)) and average (an initiative of teachers in the organization and conduct of creative classes (57.2%), self-belief (80.2%), critical thinking (59.6%)) levels.

The value of a person, in general, and teachers of foreign languages is determined by their ability and experience to meet their own needs, motivate themselves to achieve goals and desires. In other words, it means to take responsibility for your privacy. According to the study, most teachers are characterized by an average level of self-belief, their strengths and abilities, their self-worth as a teacher of foreign languages (80.2%). It may be due to various reasons and indicates problems in accepting oneself as a person, a teacher, dissatisfaction with oneself, destructive behaviour etc.

According to Dostovalov (Dostovalov, 2004), faith serves as a three-component social attitude, which, depending on the consistency of its compo-

Table 1: Levels of the value component of creativity of foreign language teachers.

Creative potential indicators	**Levels number of (respondents in %)**		
	Low	**Average**	**High**
Value component			
the value of creativity in the transformation of reality	49.0	34.6	16.3
desire for self-development	26.9	45.2	27.9
motivation to create innovative methods and techniques	75.5	19.2	5.3
positive attitude to the formation and development of creative abilities	2.4	22.1	75.5
the need to implement interesting (creative) classes	76.0	18.3	5.8
desire to be an independent person (desire for freedom)	22.1	39.4	38.5

Table 2: Levels of the cognitive component of creativity of foreign language teachers.

Creative potential indicators	**Levels number of (respondents in %)**		
	Low	**Average**	**High**
Cognitive component			
clear ideas about creativity and features of foreign language teaching	77.9	15.9	6.3
ability to produce non-trivial ideas (original)	69.2	21.2	9.6
initiative	26.4	57.2	16.3
the ability to understand and accept the individuality of another	46.2	46.2	7.2
Self-belief	14.4	80.2	4.8
Ability to understand and reflect	20.2	59.6	20.2
Critical thinking	23.1	59.6	17.3

nents (operational and reflexive), requires sufficient maturity and focuses on internal mental processes.

After all, "self-confidence may not always be reflected in a particular life situation or area due to lack of time or self-interest, a tendency to self-knowledg". The scientist notes that the individual's awareness of self-worth, the cognitive component of self-confidence is manifested first at the operational, more superficial level, and later – at the reflexive level. The ability to understand and reflect on most teachers is developed at an average level (59.6%).

The obtained results testify to the existing problems not only of knowledge and understanding of oneself but also awareness of how others understand and perceive the teacher's personality: emotional reactions and cognitive representations of personality. Only the one-fifth of the respondents (20.2%) has a high level of reflexivity, which, in turn, ensures the direction of their activity on the development of themselves as a whole, as a "system of systems" (Kostiuk, 1989); and on their characteristics on the possibilities of self-construction, self-cause, self-development and self-improvement.

The obtained results show that the respondents are insufficiently aware of the essence, the content of creativity, innovative methods and forms of foreign language teaching. Likewise, this complicates the ability of teachers to implement creativity, accept and create new, non-standard thinking, generate original and useful ideas. After all, it is the creativity of a foreign language teacher that determines their "readiness for change, rejection of stereotypes, and search for original solutions to complex problems in a situation of uncertainty" (Yakovenko, 2012).

Exploring the ability to implement creativity in the professional activities of foreign language teachers, we studied the features of the behavioural component. The obtained results 3 showed a low level of ability to take creative solutions (84.6%), to create new creative products (76.4%), to introduce innovative methods and forms (83.2%), ability to innovate, ingenuity (87%), despite the average level of self-organization of creative work (66.3%) and a high level of focus on business (70.2%) (table 3).

Thus, the behavioural component requires a significant expansion of teachers' behaviour through awareness of some common ways of teaching foreign languages, creating conditions for the effective formation and development of creative competence.

The effectiveness of professional activity of teachers relies on several individual psychological and organizational-professional factors that provide significant conditions and factors influencing foreign language teaching success.

Success factors are based on the structure of the professional activity. It allows identifying them with

Table 3: Levels of manifestation of the behavioural component of creativity of foreign language teachers.

Creative potential indicators	**Levels number of (respondents in %)**		
	Low	**Average**	**High**
Behavioural component			
The ability to take creative solutions	84.6	13.0	2.4
The ability to create new creative products	76.4	16.8	6.7
The ability to introduce innovative methods and forms	83.2	10.1	6.7
The ability to self-organize creative work	17.3	66.3	16.3
Focus on business	27.9	1.9	70.2
The capacity for innovation, creativity	87.0	10.6	2.4
The ability to manage a professional environment	31.7	42.3	26.0

its structural components, creating conditions for the development of internal motivation to generate and implement creativity, improving the educational process by creating innovative methods and techniques of teaching foreign languages.

We are impressed by the opinion of Buchatska (Buchatska, 2005) on the importance of creating such conditions under which the student would be a subject of educational activity, its active participant and creator.

Given the importance of individual psychological factors that contribute to the successful learning of foreign languages, it is necessary to teach students how to:

- work independently;
- act thoughtfully, consistently, systematically;
- build self-confidence;
- develop their professional competence;
- promote personal development, and so forth.

According to the results of the study of individual psychological factors of creativity of foreign language teachers (table 4), we revealed a low level of perfectionism (39.4%), which complicates a responsible attitude to foreign language teaching, following internal patterns and high standards. Only 39.4% of respondents strive to be the best, perfect, and unsurpassed, grow personally and professionally, motivating oneself to successful creative activity (table 4).

Besides, more than half of the teachers displayed low inadequate self-esteem (65.4%). Only 4.6% of teachers have an adequate attitude to themselves, their abilities, capabilities, orientation, activity and social significance. That is just self-esteem is a vital internal mechanism of self-regulation of behaviour and functioning, which may change in the process of operation and interaction of a foreign language teacher with the environment.

Almost half of the respondents (49%) showed the low level of adaptive abilities in interaction with people, which complicates the creating positive motivation to form innovative methods and techniques of teaching foreign languages and acceptance by teachers of norms and values of creative professional activity. Adaptive abilities register that 3.8% of respondents have convenient and modifying opportunities to interact while learning foreign languages, hence, which contribute to:

- the growth of internal motivation;
- positive changes in the value, cognitive, emotional spheres.

They display in behaviour, creativity, generation and implementation of innovative methods and forms of foreign language teaching.

Autonomy (self-government) is a personal quality insufficiently developed (39.4% - the average level), which characterizes: independence; and the ability to self-determination in decision-making and actions of the teacher to learn foreign languages based on their principles, views, values, strategies, goals, available resources and motives, etc.

According to the Vinogradova (Vinogradova, 2002), this is “the main quality of personality, which is manifested in tolerability, non-conflict, as well as resilience, trust and the ability to calmly and without irritation to accept the individuality of others”. Communicative tolerance is relevant to foreign language teachers.

Thus, communication is one of the essential tools of their professional activity, based on a friendly attitude to others and a desire to interact based on constructive dialogue in foreign language learning.

So, it is necessary to realize creativity, energy, activity, diligence and purposefulness, ability to transform the reality (Balakhtar, 2019a).

We established the average level of development of communicative tolerance (67.8%) as the most typical for foreign language teachers. This indicates the ability to not fully interactively use language and

Table 4: Levels of manifestation of individual psychological factors of creativity of foreign language teachers.

Creative potential indicators	**Levels number of (respondents in %)**		
	Low	**Average**	**High**
Individual psychological factors			
perfectionism	39.4	21.2	39.4
self-esteem	65.4	34.6	-
adaptive abilities in interaction with people	49.0	47.1	3.8
Autonomy (self-government)	24.0	39.4	36.5
Communicative tolerance	32.2	67.8	-

other means of communication (a range of interactive technologies, skills and abilities to function in socially heterogeneous groups). Thus, the results indicate the probability of not always successful interaction, cooperation in teaching foreign languages (table 4).

In our opinion, the development of creativity of foreign language teachers is influenced not only by individual psychological factors but also by organizational and professional ones, namely: professional workload, professional compression, ability to constructive resistance.

Thus, 20% of the studied teachers showed a high level of professional workload; 25% of people experience professional stress while teaching foreign languages; 27.9% of respondents are capable of constructive resistance (table 5).

Summarizing the results of the empirical study of value, cognitive and behavioural components, the following levels of creativity of foreign language teachers, in general, were identified: above average (10.6%), average (42.3%), below average (37.0%) and low (10.1%) (table 6).

At the ascertaining stage of the empirical study, there were no foreign language teachers with a high level of creativity. At the same time, the results of ANOVA revealed statistically significant differences in the manifestations of creativity of foreign language teachers depending on their gender and age (figure 1, $p < 0.05$) and organizational and professional characteristics (figure 2, $p < 0.01$). Thus, teachers of foreign languages, both female and male, have a tendency by creativity at the level to increase in ($p < 0.05$).

We suppose that the increase of creativity of foreign language teachers with age comprehends through: holding a higher position; obtaining a degree and academic title; respectively higher pay; higher social status; more opportunities to meet the needs of teachers, i.e. a more inclusive balance between contributions efforts and benefits, although not enough.

We may assume that the insufficient level of creativity is due to the introduction of mass distance teaching in a pandemic of the COVID-19 in higher education institutions. It has led to an increase in the working teacher's load upon digitalization of education (Tkachuk et al., 2021; Velykodna, 2021; Velykodna and Frankova, 2021).

The teacher is forced, in addition to teaching foreign languages, to master: new digital tools by the model of digitization chosen by the institution of higher education; ICT and learning tools; new roles, tasks and activities; new methods, forms and techniques of distance teaching; and to establish effective communication of all participants in the educational process on network platforms, etc. (Areshonkov, 2020).

Besides, the peculiarities of the creativity of teachers of foreign languages, depending on the position, show that, in general, creativity grows with increasing professional status (figure 2, $p < 0.01$).

This is probably due to different requirements for the professionalism of teachers (assistant, senior lecturer, associate professor, professor), as well as "the urgent need for a radical change of emphasis on professional competencies of teachers in the transition to digital universities and distance education in particular" (Areshonkov, 2020, p. 3).

The results are consistent with the JD-R model, in which professional activities include requirements and resources (Demerouti et al., 2001, p. 501).

Authors defined the Job requirements as "aspects of the job that require sustained physical or mental effort and are therefore associated with certain physiological and psychological costs".

The higher the status of the teacher, the presence of a scientific title, scientific degree – diversify the opportunities of teachers in the implementation of creative activities, the higher the level of autonomy, interaction. At the same time, the lower the status of the teacher, the fewer opportunities he/she has and the more work overload. This, in turn, causes stress, conflict and insecurity and can lead to burnout. According to the JD-R model, stresses arise due to an imbalance between the requirements of professional activ-

Table 5: Levels of manifestation of organizational and professional factors of creativity of foreign language teachers.

Creative potential indicators	**Levels number of (respondents in %)**		
	Low	**Average**	**High**
Organizational and professional factors			
Professional workload	30.8	49.0	20.2
Professional stress	40.4	34.6	25.0
Ability to constructive resistance	34.6	37.5	27.9

Table 6: Levels of manifestation of components and factors of creativity of foreign language teachers.

Components and factors	**Levels of manifestation of components of creativity, in %**				
	low	**below average**	**average**	**above average**	**high**
Value component	6.3	47.1	34.1	12.5	
Cognitive component	0.5	41.8	51.9	5.8	
Behavioural component	10.1	62.0	23.6	4.3	
Individual psychological factors	11.5	25.0	54.3	9.1	
Organizational and professional factors	26.0	3.8	39.4	28.8	1.9

ity and the resources that the teacher invests to meet these requirements (Schaufeli and Salanova, 2011).

We established statistically significant differences in the creativity of foreign language teachers leaning on the language of teaching. Thus, the study results of teachers' creativity while teaching English showed lower rates than teachers of other foreign languages, including French. So, teachers may implement the creative approach in the teaching of foreign languages; and language is a means of communication that is studied through the personal activities of students. Typical tasks are search and creative, for instance:

- filling information gaps;
- role-playing games;
- solving problems, and so on.

Typical forms of work are group and pair work, which contribute to the formation of a creative personality of both student and teacher. After all, it is impossible to teach something if you do not own it yourself. The use of interactive forms and methods of work helps to form a positive interdependence and individual responsibility. Face-to-face interaction creates a collective and friendly skill. The process of working in groups or pairs is always creative and exploratory: the task is set before the group, and everyone has an incentive to excel and make a contribution. The use of group forms of work creates conditions for both the development of thinking and for self-affirmation.

We assumed that the creativity of foreign language teachers affects their life satisfaction and subjective well-being in general. Hence, teachers of higher educational institutions have to achieve subjective and psychological well-being, "strive to develop their personal potential, to create positive relationships, to engage in productive and creative activity, to use their creative abilities to generate innovative ideas, improve their well-being and satisfaction with life, work and self-develop" (Androshchuk et al., 2020). According to the results of ANOVA, we found statistically significant differences in subjective well-being depending on the level of development of creativity of foreign language teachers (figure 4, $p < 0.01$).

Figure 4 shows that teachers with a higher level of creative potential development show higher indicators of subjective well-being. This means that:

- they feel happy and confident;
- they are able to adapt to changing the professional conditions;
- they are motivated to implement creative methods and techniques for the development of value, cognitive and behavioural components of individual psychological and organizational-professional factors of creativity of foreign language teachers.

In our opinion, it is impossible to achieve subjective well-being without enthusiasm for one's work, without motivating oneself to achieve success, professional growth, positive attitude to oneself as a teacher, a person. Therefore, in our opinion, it is expedient to develop a training program for the development of creativity of foreign language teachers to achieve their subjective well-being and success in professional creative activity.

The training program "Development of creativity of a foreign language teacher as a factor of their subjective well-being" consists of 5 sessions aimed at the development of value, cognitive and behavioural

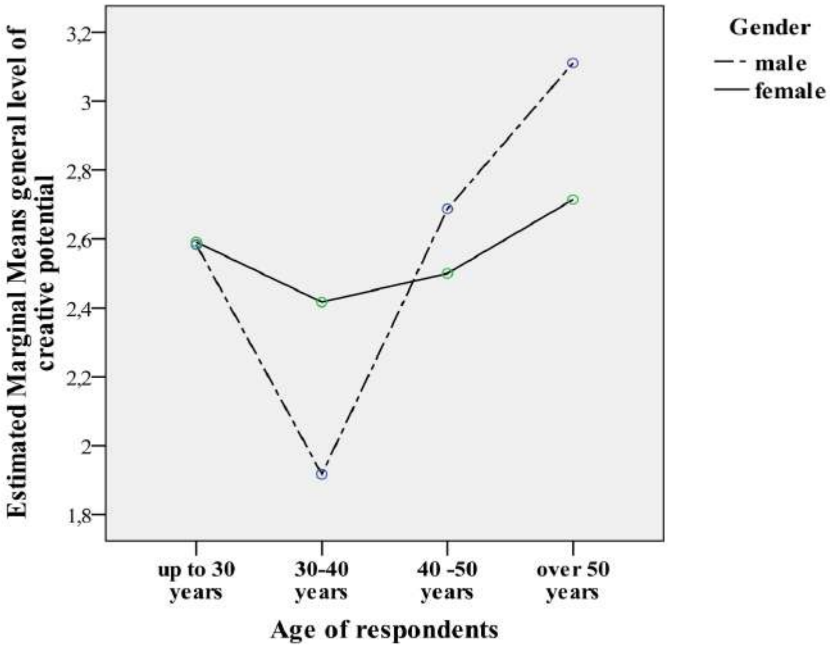

Figure 1: The peculiarities of psychological safety of the educational environment of participants in the educational process depending on gender and professional status ($p < 0.05$).

components and individual psychological and organizational and professional factors. Each session contains informational, diagnostic, developmental and creative stages. Each stage involves tasks of different types and kinds of complexity (interactive lectures, thematic discussions, use of questionnaires, surveys, methods ("Creativity" (Nikiforov et al., 2003), "Your creative potential" (Rogov, 1999), "Diagnosis of communicative tolerance" (Boyko, 1998), methods of measuring reflexivity (Karpov, 2003), etc.), the method of incomplete sentences, developmental exercises ("Creativity", "Creative qualities of a teacher of foreign languages", "Believe in their creative abilities", "16 associations", "Alphabet", "Creative life", "Suitcase, basket, meat grinder", "Teacher's creative personality", "Life situations", "Visualisation", "Drawing of professional "I", "Realization of professional skills", "To be a teacher", "Experience of my mistakes", "Who we are in a changing world", etc.), conducting organizational and activity games, performing creative tasks, etc.

The first session aims at forming a value attitude to the constructive transformation of reality and promotes the development of the value of creativity for the individual; striving for self-development and being an independent person; the development of motivation to create innovative methods and techniques; positive attitude to the formation and development of creative abilities; needs for the implementation of interesting (creative) classes.

The second session involves the formation of knowledge, awareness and understanding of the peculiarities of teaching foreign languages through the use of creative technologies: expanding ideas about creativity, innovative methods and forms of teaching foreign languages; ability to produce non-trivial ideas (original); to show initiative in the organization of creative activity; ability to understand and accept the individuality of another person; self-believe and the ability to understand and reflect; think critically.

The third session promotes the creative effectiveness of teaching foreign languages, namely the ability to make non-standard decisions, create new creative products, self-organization of creative work; to introduce innovative methods and forms; focus on business; be capable of innovation, ingenuity, management of the professional environment.

The fourth and fifth sessions aim at the development of individual psychological and organizational-professional factors, which promote the development of creativity and motivate foreign language teachers to achieve subjective well-being and success in professional creative activity.

5 CONCLUSIONS

Thus, the results of the study revealed an insufficient level of formation of cognitive, value and behavioural components and individual-psychological

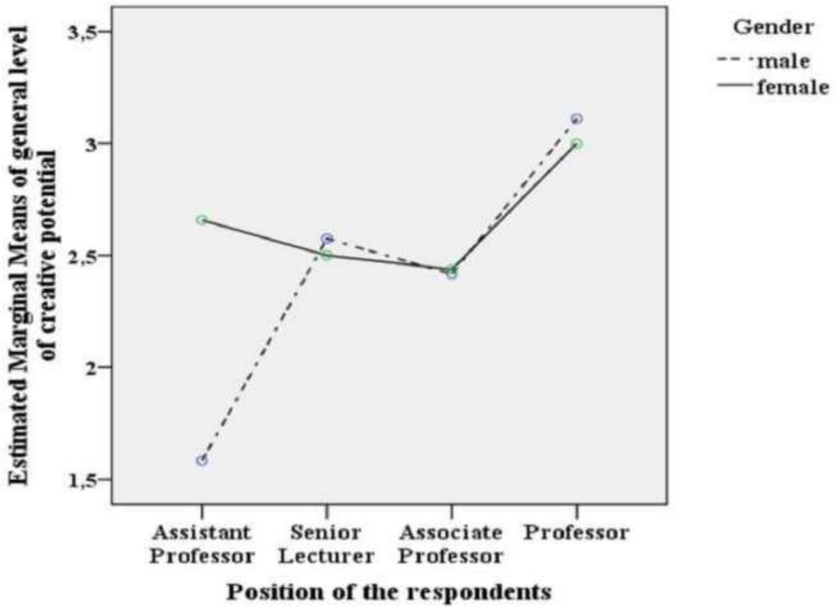

Figure 2: Features of creativity of foreign language teachers depending on the position ($p < 0.01$).

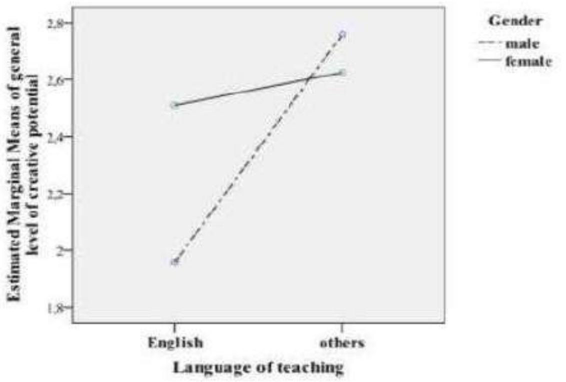

Figure 3: Features of creativity of foreign language teachers depending on the language of instruction ($p < 0.01$).

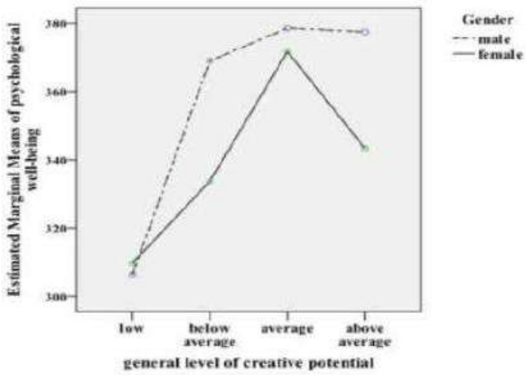

Figure 4: Features of creativity of foreign language teachers depending on the subjective well-being ($p < 0.01$).

and organizational-professional factors of creativity of language teachers. According to the results of an empirical study of the value component of creativity, we have identified a low level of development of the value of creativity, the transformation of reality, motivation to create innovative methods and techniques, the need to implement interesting (creative) activities. The high level is revealed only by the indicator of a positive attitude to the formation and development of creative abilities.

We revealed an insufficient level of development of the cognitive component of creativity of foreign language teachers, namely: low level of clear ideas about creativity and peculiarities of foreign language teaching, ability to produce non-trivial ideas (original), ability to understand and accept the individuality of another. The study revealed the average level of the initiative of teachers in the implementation of creative activities, self-belief, and ability to understand and reflect, critical thinking. The low level was characteristic of the relevant behavioural component of the creativity of foreign language teachers, namely: the ability to make non-standard decisions, create new creative products, implement innovative methods and forms, be innovators, and show ingenuity. The results showed an insufficient level of manifestation of the development of creativity of foreign language teachers depends to a large extent on individual psychological factors (perfectionism, adaptive abilities in interaction with people, autonomy) and organizational and professional factors (professional workload, professional compression, communicative tolerance, ability to constructive resistance).

We consider the development and testing of the program an urgent need for their psychological support and additional support in the development of the components of creative potential, the ability to think critically, establish contacts and interact, be creative, creative individuals.

Besides, we came up with the following way of solving the current problem in the future, i.e. to test and develop the program to promote the creativity of teachers of foreign languages.

We offer the structure of the program of development of creativity of the foreign languages teacher consisting of 5 sessions directed on the development of value, cognitive and behavioural components and individual-psychological and organizational-professional factors. The program contains informational, diagnostic, developmental and creative stages that promote the development of creativity and motivate foreign language teachers to achieve subjective well-being and success in professional creative activities.

Prospects for further research on this issue are the extension of the criteria and methods for studying the effectiveness of the training program "The development of creativity of foreign language teachers as a factor in their subjective well-being".

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Build a Technology for Mass Organization of Distance Learning for Pupils in Quarantine

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Keywords: Moodle Platform, Distance Learning, Distance Course, Tutor.

Abstract: The current state of implementation of distance learning in general secondary education institutions and the existing disadvantages in the organization of this form of education during quarantine were analyzed in the research; besides, the necessary means for the effective organization of distance learning were allocated. The expediency of the deployment on the basis of the Moodle platform "Educational portal for general secondary education institutions" was substantiated and the preconditions for its using by the participants of the educational process of these institutions are determined; the structure of the electronic educational resource is presented. It is established that it is much better for students to use the weekly format of the course, which provides enough time for any student not only to learn educational materials either independently or with the support of a tutor according to the curriculum, but also for homework, recreation, hobbies and self-improvement. An example of the structure of a distance course for a particular class of general secondary education is given. Compulsory content elements in the structure of the distance course are distinguished.

1 INTRODUCTION

1.1 The Problem Statement

The question of the probable existence of distance education is no longer relevant. The distance education exists all over the world and occupies a socially-significant place in the field of education (Lénárt, 2021). At the end of 1997, there were about 1,000 distance learning institutions in 107 countries. In 1997 the number of those who received higher education due to the distance education system was about 50 million people, in 2000 the quantity increased, it was 90 million people, according to the forecasts it will be 120 million people in 2023 (Tatarchuk, 2020).

In 2013, the Order of the Ministry of Education and Science approved the "Regulations on distance learning" (Verkhovna Rada of Ukraine, 2013), which defines the basic principles of organization and implementation of distance learning in Ukraine.

Because of the threat of the spread of coronavirus COVID-19 in Ukraine, the Cabinet of Ministers introduced the quarantine measures, prohibiting attending the educational institutions throughout the country since 12 March 2020 (Verkhovna Rada of Ukraine, 2020; KMU, 2020).

In such circumstances, the heads of educational establishments and also preschool, general secondary institutions, vocational and technical education, professional higher and postgraduate education are obliged to ensure the organization of the educational process on the basis of distance learning technologies for the period of quarantine (MON, 2020).

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Most teachers are aware of this form of organization of the educational process, but only a few have used its elements in their professional activities or for self-education. However, nowadays teachers must quickly and effectively use the latest technologies, methods and forms of learning and studying.

The creation of an educational portal with methodological and didactic materials, Ukrainian e-encyclopedias, multimedia textbooks and interactive online resources was provided within the reform of education and science, to help teachers to cope with everything (KMU, 2018).

1.2 Related Works

The National Report on the Status and Prospects of Education Development in Ukraine points out that "effective development of education is possible only if all components of pedagogical systems, including informational and educational environments of educational institutions, are modernized based on the implementation of anthropocentrism paradigms and equal access to the quality education. Among the important directions as for the development and improvement of the education system, the problems of informatization of the educational process are of particular importance, it allows expanding and deepening the theoretical knowledge base and creating effective computer-based methodological systems of education" (MON, 2016).

The primary task, defined in the Concept of Digital Economy and Society of Ukraine for 2018–2020, is the formation of a thorough national policy of digitalization of education as a priority component of education reform, one of the main directions of which is the development of distance education using cognitive and multimedia technologies (Verkhovna Rada of Ukraine, 2018).

Bykov (Bykov, 2008) notes that among the most modern educational technologies that have actively declared themselves at the end of the 20th century and have become really widespread in developed countries nowadays there are distance learning technologies that support and provide distance education. Besides the distribution of the world educational space takes place and distance education plays a leading role in this process, significantly diversifying the market of educational services.

The scientific researches of Ukrainian and foreign scientists cover theoretical, methodical, technological, as well as practical aspects of providing distance learning of pupils, students, teachers and others. Thus Bykov and Shyshkina (Bykov and Shyshkina, 2014), Kukharenko (Kukharenko, 2013a,b; Kukharenko and Oleinik, 2019) and others analyzed the available normative implementation of distance education and the recommendations for the formation of draft documents "Regulations on distance learning in the system of general secondary education" and "Standard regulations on the resource center of distance education in the system of general secondary education" are developed.

The peculiarities of the organization of distance learning and the requirements for the usage of distance learning platforms in the institutions of postgraduate pedagogical education were determined in (Petrenko et al., 2020). The basics of the use of distance learning technologies in the training of future specialists and teachers in particular were described in (Bondarenko et al., 2018; Shokaliuk et al., 2020; Tryus and Herasymenko, 2021). The pedagogical and information support of distance learning is characterized in (Havrilova et al., 2019; Kravtsova et al., 2020; Kushnir et al., 2020).

At the same time, the problem of distance learning for students of general secondary education is not fully resolved. There are some researches, dedicated to the technology of the organization of mass distance learning in the whole at the level of teachers of individual subjects (student-tutor), each of them worked relatively isolated from colleagues (volumes and deadlines coordination).

Instead, Reynolds (COVID-19 and Extended Online Learning, 2021) notes that during the quarantine period, the so-called "emergency distance learning" is introduced, which is not identical to distance learning. The scientist notes that "the main purpose of such kind of training is to provide temporary reliable access to studying and pedagogical support during the crisis, but not to create a reliable educational ecosystem. This is a triad situation: extraordinary and accountable goals, students' expectations of teacher assessment and evaluation. Mostly lower in quarantine conditions" (COVID-19 and Extended Online Learning, 2021).

We partly agree with Reynolds (COVID-19 and Extended Online Learning, 2021), as an outbreak of a coronavirus pandemic, according to epidemiologists, can last for several years; moreover, outbreaks and other infections, unknown to mankind, are also not ruled out. So, it is really necessary to organize an effective system of distance learning for students during the quarantine, elements of which can be successfully used in traditional and inclusive education.

Nowadays, under such special conditions (for education organizers, teachers and students) as (Reshchuk and Lukashova, 2020): lack of opportunity to use other forms of education, lack of access to the premises of educational institutions, in isolation under quarantine restrictions, – there are problems at the institutional level – at the level of the educational institution there is a requirement for more coordinated organization of the educational process, including the selection and usage of not only one or a limited number of platforms by teachers within the educational institution taking to the consideration the required level of informational security and health, but also the selection of "home-setting" recommended means which might be installed outside the educational institution on students' personal devices to work with files of certain types and formats.

This applies also to teachers, the vast majority of whom must use their own software / hardware ICT tools, serve and maintain them in working condition at their own expense, and also provide a proper access to the Internet. At the same time, the problems and tasks of the institutional level may be increased by the difficulties of the regional level connected with different levels of infrastructure development of different territories, communities, settlements and their individual areas, including low speed and quality of data transmission in relevant segments of the Internet, and even sometimes lack of access to network itself.

All this requires the development and using of appropriate scientific and methodological support for the implementation of mass distance learning at the institutional level in quarantine.

The purpose of the research is to build a technology for mass organization of distance learning for pupils in quarantine on the basis of the Moodle platform.

1.3 Research Methodology

To achieve the goal, such research methods were used as: theoretical – analysis of regulatory documentation as for the organization of the educational process in institutions of higher and general secondary education, educational development in Ukraine, the introduction of distance learning; survey of pedagogical workers as for the current state of the organization of distance learning in general secondary education; identification, analysis, systematization of affiliation of fulfilling the functions by the tutor; empirical - conversations with participants of the educational process of general secondary education institutions; direct, indirect, included monitoring the implementation of distance learning in general secondary education institutions; method of expert assessments, etc.

2 RESEARCH RESULTS

2.1 Basic Concepts

Distance form of education is an individualized process of education, which occurs mainly through the indirect interaction of distant participants in the educational process in a specialized environment that operates on the basis of modern psychological, pedagogical and information and communicative technologies (Verkhovna Rada of Ukraine, 2017).

Bykov defines that distance learning is a form of organization and implementation of the educational process, in which its participants carry out educational interaction (both synchronously and asynchronously in time) mainly extraterritorially on the basis of digital technologies (Kremen, 2008).

An online course is a set of educational and methodical materials and educational services created in a virtual learning environment for the organization of distance learning based on information and communication technologies (Bykov, 2008).

Studying, using online course is an interactive process, based primarily on the paradigm of modern education, which aims to create an interactive communicative network space, identify individual characteristics of each participant, and of course stimulate him to find an independent solution to any problem, moreover it encourages to self-education (Kukharenko et al., 2005).

2.2 The Structure of the Distance Course

The main components of the distance course are:

- the system of educational and methodical materials;
- the system of educational services.

It is desirable to have a structure in online course that will help create conditions for learning in activities and cooperation.

For students of general secondary education institutions, it is best to use a weekly course format – which provides time for students to study educational materials independently or with the support of a tutor in accordance with the curriculum, for homework, for recreation, hobbies and self-improvement. Therefore, while developing a distance course for students of general secondary education institutions it is necessary to take into account this principle.

In figure 1 an example of the structure of a distance course for a particular class is shown. This structure provides:

1. The entire period, while distance learning, is divided into weeks: the dates of each of school weeks are indicated (March 30 - April 5, April 6 - April 12, etc.);
2. In each of these weeks the days for studying (from Monday to Friday) with the indication of the date (Monday (March 30), Tuesday (March 31), etc.) are indicated;
3. In each of the days the training sessions and their duration are indicated according to the schedule;
4. Teachers fill in with the content each of these classes, choosing the necessary activities (tasks, test, choice, seminar, etc.) and resources (page, file, URL-link, etc.).

The distance course, located in a virtual learning environment, provides: learning process management and administration; providing knowledge by studying theoretical material; self-control; the formation of skills and abilities on the basis of the received knowledge; fixing the material; joint activities of students in small groups; synchronous and asynchronous communication; control the learning and understanding of theoretical material; doing of practical tasks and their control (Kukharenko et al., 2005).

2.3 Tutor as an Organizer and Leader of the Distance Learning

In distance learning, a tutor is an important person responsible for conducting classes with students, creating an appropriate learning environment. A tutor manages the learning process as an activity and tries to provide the planned results both in the acquired knowledge and skills and the acquired personal abilities of students (Kukharenko et al., 2005).

It is really difficult to adapt learning materials to the requirements of students, because these requirements often become known during the training itself. Therefore, the adaptive role is usually performed by the tutor.

A tutor is often more than a source of information. Tutor can help the student to become sufficiently autonomous, it can teach to learn independently.

The distance course tutor does much of what a teacher does in traditional teaching, for example, leading a group in a discussion using effective techniques. However, it works in an electronic environment where participants are not placed in one real room at a certain time. The tutor teaches to communicate, using different styles, approaches, language means of communication, examples, questions that are used to improve the learning process in the group (Kukharenko et al., 2005).

Most teachers believe that learning to manage distance learning is just mastering some new software or developing computer skills, that is, to add information technologies to an established learning system. This is a misconception.

Successful distance learning management cannot be achieved through classroom experience only. Tutor skills cannot be acquired due to the lectures or observations primarily because they contain many areas, directions and responsibilities that are rarely used and we don't observe them in traditional teaching (Kukharenko, 2007).

For the organization of distance learning in an educational institution, it is important that the tutor has the following basic competencies:

- to know the basics of telecommunicate etiquette;
- to have informational navigation skills;
- to be able to work with LMS;
- to be able to create web pages;
- to have a certain computer-based learning environment (CBLE);
- to be able to use a range of services provided by this environment;
- to be able to present educational material, to ensure effective, individual, independent of the place and time, student's work;
- to know the methods of intensification of the student's activity in the network, and to be able to use them during the distance learning;
- to know the peculiarities of students independent activity during distance learning;
- to be able to conduct psychological and pedagogical testing and analyze the current activities of students;
- to be able to prevent and solve conflict situations;
- to know active teaching methods (collaborative learning, project method, multilevel learning, research, search methods, etc.);
- to be able to conduct role-playing online games;
- to help students to be active in a computer-based learning environment, systematically to motivate students to learn;
- to provide a personal approach, give some advice and consultation, etc.;
- to determine the effectiveness of students' learning activities through feedback;
- to determine the necessity for the formation and development of new subject competencies of students, in accordance with the content of education, and also to be able to improve its quality;

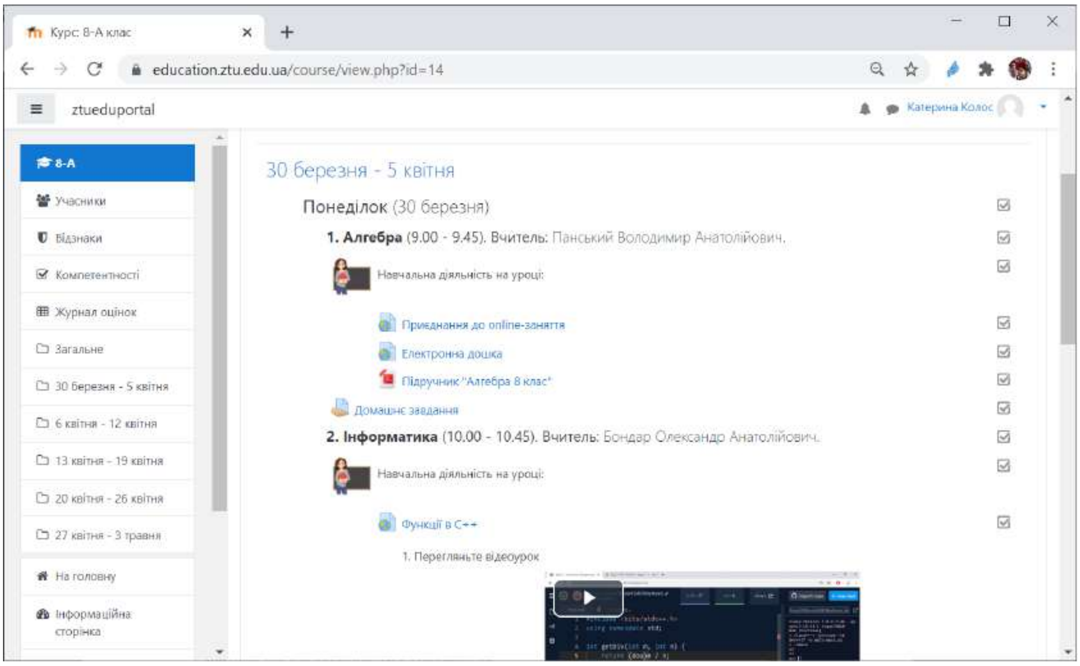

Figure 1: An example of the structure of a distance course.

- to determine the level of assimilation of new knowledge and skills by students within the subject;
- to carry out high-quality content of distant course, as well as pedagogically balanced selection of ICT used during the training;
- to identify the problems with student registration, record and notation keeping, etc.
- to be able to integrate full-time and distance learning;
- to master a method of forming systemic thinking, including critical thinking, and also the student reflection, as a means of evaluation of their activities for further improvement;
- to be able to organize and conduct online classes in real time;
- to use actively the communicative capabilities of computer networks to organize communication among the participants in the learning process;
- to be able at least to adjust and correct the existing courses according to the new requirements of the educational process, if there is no opportunity and possibility to create a new one.

In addition to the competencies, mentioned before, a considerable attention must be paid to the issues, related to subject-subject relationship in the learning process, pedagogical approach and support, opportunities for communication, adaptation, motivation and learning management.

The quality of distance learning mostly depends on the skills of the tutor, who must effectively direct the group and individual learning process in the right direction. A competent tutor is able to create a learning environment where the participants together define the essence, generate ideas and understanding.

In general, the tutor's activity is a model of systematic organization of learning, which involves combining the perception of theoretical information with their transformation into personal knowledge, as well as the widest expansion, distribution and deepening of this knowledge by students (through analysis and search) during practical implementation.

2.4 Student as the Main Person in Distance Learning

The main person of distance learning is a student, so the effectiveness of learning must be assessed according to the following indicators:

- the attitude of students to distance learning;
- the student satisfaction with the learning process;
- the student achievement.

As a rule, the student feels comfortable in the learning environment, if he is responsible enough for learning (Kukharenko et al., 2005):

- sets real goals;
- monitors his/her progress;
- reflects understanding;
- finds a good support both among tutors and classmates.

The main condition and contribution for the student success in DC is a high level of motivation and self-discipline. Additional factors of learning success are the willingness to ask for help and a responsible attitude to distance learning.

Students evaluate the quality and positive features of interaction with the tutor, based on reliable and timely feedback.

The tutor must understand and take into account while organizing distance learning that the student needs some help at all stages of learning.

At the beginning of the student's studying, it is necessary to get acquainted with the structure and content of the distance course.

The tutor should be able to characterize thoroughly the main basics of the training course, to help with establishing communication among the participants of the distant course.

The tutor's advice on planning educational activities, its organization, formation and improvement of learning skills, the process of learning technical and informational means of learning is extremely important for students. During the studying, students need some advice on (Kukharenko et al., 2005):

- planning the schedule of the day;
- self-organization;
- improving learning skills;
- learning a new means of information transfer;
- solving technical problems;
- doing some educational tasks;
- non-formal learning with other students;
- self-assessment of the quality of the studied material;
- fulfillment of the tutor's requirements;
- doing some tests, control tasks.

As everybody knows students can differ significantly in the style of perception, processing and using of the information in educational activities, as well as in the ability to communicate and collaborate, so the tutor needs to use a differentiated approach to work with students.

Not to provide the assistance in technical and organizational matters in time is the most disorganizing for students. It creates a feeling of confusion, anxiety and frustration, the contradiction in the interpretation of instructions appears when students do not receive a quick feedback of their tutor.

It is often believed that all difficulties disappear in the first weeks of training. However, the research shows that students may experience anxiety and frustration at later stages of the course, but they are afraid to write to the tutor about it. So, the tutor must be able to predict the possible complications in the processing of this or that material for the student in the learning process and prevent them in the methodological developments (Kukharenko et al., 2005).

2.5 Distance Learning Tools

Current distance learning is based directly on the information and communication technologies, so the organization of distance interaction among participants in the learning process requires not only connection and free access to the Internet, but also the availability of software.

For the effective implementation of distance learning in educational institutions, one of the key tasks is pedagogically balanced selection of software taking into account the demands and capabilities of the educational institution. On the basis of this software not only distance communication between tutors and students must be implemented, as well as to provide access to electronic educational resources for educational purposes, but also maintain the appropriate level of education.

To study the current state of the organization of distance learning in general secondary education from 8 to 22 April 2020, a survey of teachers of Zhytomyr region (Survey, 2020) was conducted, which was attended by 2445 respondents, among them: 63% – subject teachers of the 5th–11th grades, 20% – primary school teachers, 8% – principals and deputy principals, 2% – teacher assistants and 7% – other teachers (educators of extended day groups, teachers, organizers, psychologists, social educators) (figure 2).

Since the total number of teachers of general secondary education institutes in the region is more than 20,000 people, so, in accordance with the recommendations as for the formation of the sample (Survey, 2020), the available group of survey participants is representative, and the results are 95% reliable.

According to the results of the survey, 2% of respondents noted that they had not organized the distance learning system for students yet, and 2% of respondents partially use distance learning technologies (figure 3).

At the same time, 96% of respondents carry out regular distance learning, among which 89% have in-

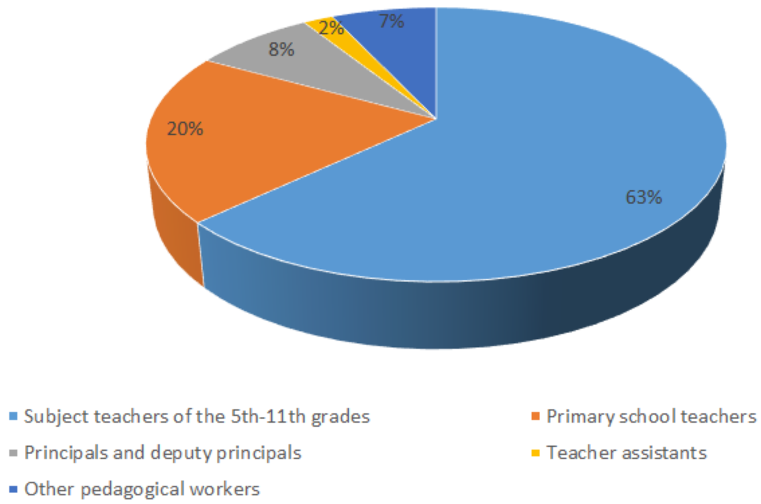

Figure 2: Distribution of respondents according to the positions.

troduced this form of education only since March 12, 2020 (since the introduction of quarantine throughout Ukraine) (figure 3).

83% of teachers have the necessary technical support and equipment, but the biggest problem for distance learning participants is the lack of high-speed Internet access. Also, for the implementation of distance learning, each teacher of Zhytomyr region uses only those software tools which he knows and can use to implement the planned activities during distance learning, in particular:

- For message distribution and file exchange: 92% – Viber, Telegram, 61% – e-mail; 51% – social networks, 9% – Google Classroom;
- For the presentation of educational material: 90% – Google cloud services (YouTube, Drive, Slides, Docs, Sites, Classroom), 25% – Zoom, 20% – educational platforms (“My class” and others);
- To monitor students’ learning activities: 42% – Viber, 16% – e-mail, 14% – Google Classroom, 13% – “My class”, 10% – Google Forms and others.

However, according to our observation, it is difficult for students to acquire new knowledge and skills, using such a variety of ICT for distance learning, besides it overloads them and disorganizes. The lack of a single learning environment in such kind of “distance learning”, where there is a proper schedule of classes, established the system of interaction among students and independent educational activities of students, so in other words it distracts students’ concentration, attention, reduces motivation to learn, increases mental stress, and of course, it negatively affects learning outcomes. It is necessary to conduct thorough psychological and pedagogical research on these issues.

It is important that only 59% of respondents use special distance learning platforms for the implementation of distance learning in general secondary education institutions, in particular: 37% – Google Classroom, 20% – “My class”, 2% – Moodle (figure 4).

Each of the platforms chosen by pedagogical staff contains the necessary means for the implementation of the digital learning process. As we can see looking at the obtained data, the numerical value of the levels as for the manifestation of the criteria for the selection of distance learning platforms for general secondary education institutions are the lowest in “My class”:

- Organizational criterion: 0.08;
- Training and resource criterion: 0.1;
- Constructive criterion: 0.08;
- Analytical and evaluation criterion: 0.16.

In general, according to all the criteria for selecting distance learning platforms for general secondary educational institutions, the numerical value of the level of manifestation in “My Class” is 0.42.

Higher numerical values of levels as for the manifestation of the criteria for selection of distance learning platforms for educational institutions are observed in Google Classroom:

- For personal account:
  - Organizational criterion: 0.10;
  - Training and resource criterion: 0.20;
  - Constructive criterion: 0.15;
  - Analytical and evaluative criterion: 0.10.

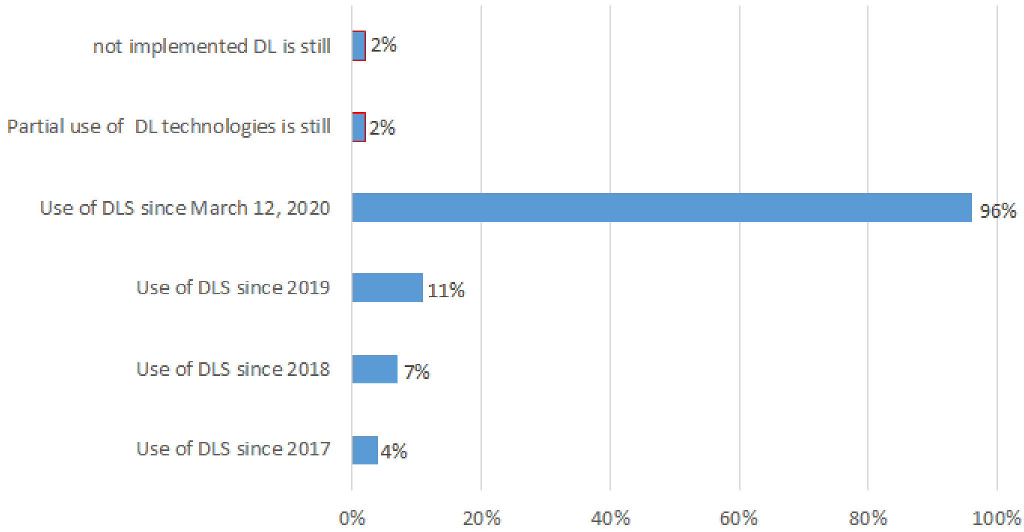

Figure 3: Use of distance learning system by pedagogical workers.

- For the account of the educational institution:
  - Organizational criterion: 0.10;
  - Training and resource criterion: 0.22;
  - Constructive criterion: 0.15;
  - Analytical and evaluative criterion: 0.10.

In general, according to all the criteria for selecting distance learning platforms for general secondary educational institutions, the numeral value of the level as for the manifestation in Google Classroom for a personal account is 0.55, and for an account of an educational institution – 0.57.

At the same time, we can see that the "My Class" platform has a bit higher numeral values in terms of the level of the manifestation of the constructive criterion than Google Classroom, while Google Classroom has insignificant advantages in terms of learning and resource criteria.

The highest numerical values of the level of manifestation of the criteria for the selection of distance learning platforms for educational institutions belong to Moodle platform:

- Organizational criterion: 0.11;
- Training and resource criterion: 0.31;
- Constructive criterion: 0.21;
- Analytical and evaluation criterion: 0.22.

On the whole, according to all the criteria for selecting distance learning platforms for general secondary educational institutions, the numeral value of the level of the manifestation in Moodle is 0.84, which indicates the significant advantages of the Moodle platform and the advisability of its using in general secondary education.

To use the Moodle platform, it is necessary to deploy it on the servers of the educational institution. However, most educational institutions do not currently have the technical and financial capacity to do it.

Therefore, on the basis of technical means of the State University "Zhytomyr Polytechnic" the electronic resource "Educational portal for general secondary education institutions" (http://education.ztu.edu.ua/) was established and developed, based on the Moodle platform, besides it can be used by any institution.

2.6 The Background for the Usage of the "Educational Portal for General Secondary Education"

To give the opportunity for teachers of general secondary education institutions to use this electronic resource, it is necessary:

1. General secondary education institution to apply to the State University "Zhytomyr Polytechnic". To do this, it is compulsory to fill in the form according to the sample: https://bit.ly/3duqfcK.
2. After the registration of this or that general secondary education institution on the specified portal, the responsible person of an establishment gets the login and the password of the administrator.

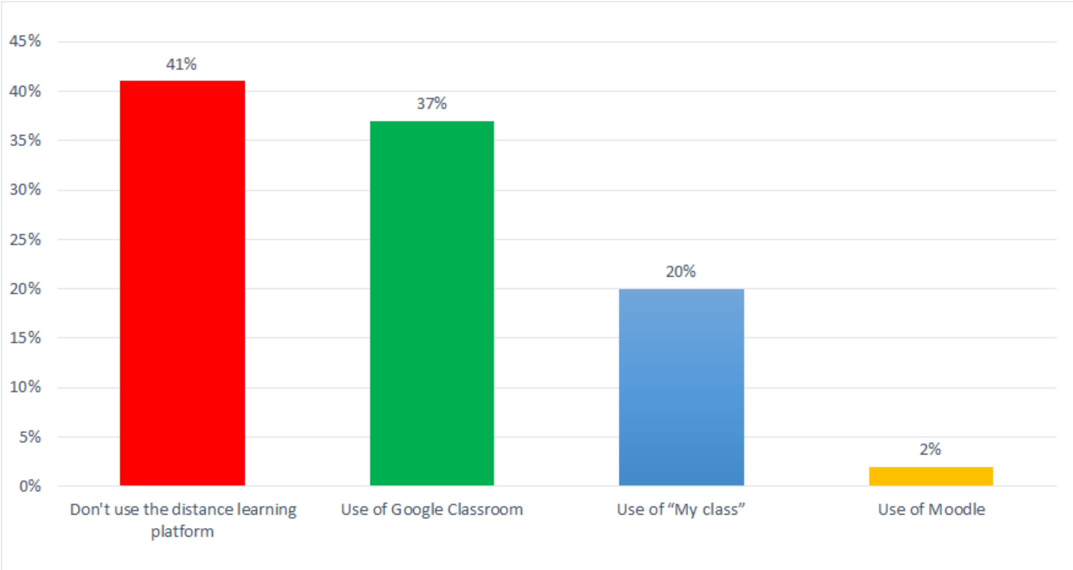

Figure 4: Use of distance learning platforms by pedagogical staff.

3. Then the responsible person of general secondary education institution having identified himself/herself (using the provided login and the password) on "Educational portal for general secondary education institutions" will have an opportunity to register all the participants of distance learning of the establishment: teachers, lecturers, masters and pupils.
4. Thus, each participant will be able to access the definite electronic educational resource according to their login and password: teachers will have the opportunity to create and fill in the content of distance courses, and in the future – to carry out direct distance learning of students based on these courses.

After scanning the application, submitted by general secondary education institution, the State University "Zhytomyr Polytechnic" creates a subcategory with the name of the registered institution of general secondary education (for example, Secondary school I–III degrees No. 33 of Zhytomyr) in the category of the relevant administrative unit (for example Zhytomyr), where the responsible person of the registered institution has the opportunity to allocate subcategories – parallels (for example: 5th grade, 6th grade, 7th grade, 8th grade, etc.) and to create some definite distance courses according to the names of the classes (for example, 8-A, 8-B, etc.) (figure 5), and teachers will be able to fill with the content these courses in accordance with the curriculum, selected forms and developed programs (figure 1).

General education institutions of Zhytomyr (17) and Vinnytsia (2) regions have joined the "Educational portal for general secondary education institutions" on January 18, 2021 including:

- Zhytomyr:
  - Secondary school of I–III degrees No. 33;
  - Zhytomyr private gymnasium "Or Avner";
  - Zhytomyr local lyceum No. 1 of Zhytomyr City Council;
  - Zhytomyr local lyceum No. 2 of Zhytomyr City Council;
  - Zhytomyr Technological College of Kyiv National University of Construction and Architecture.
- Berdychiv:
  - Berdychiv Vocational College of Industry, Economics and Law;
  - Berdychiv educational complex No. 4.
- Korosten:
  - Secondary school No. 11.
- Olevsk:
  - Olevsk secondary school of I–III degrees No. 3.
- Berdychiv district:
  - Starosolotvyn institution of general secondary education of Hryshkivtsi village council;
  - Ivankivtsi secondary school of I–III degrees of the Department of Youth Education and Sports of Semenivka village council.
- Lyubar district:

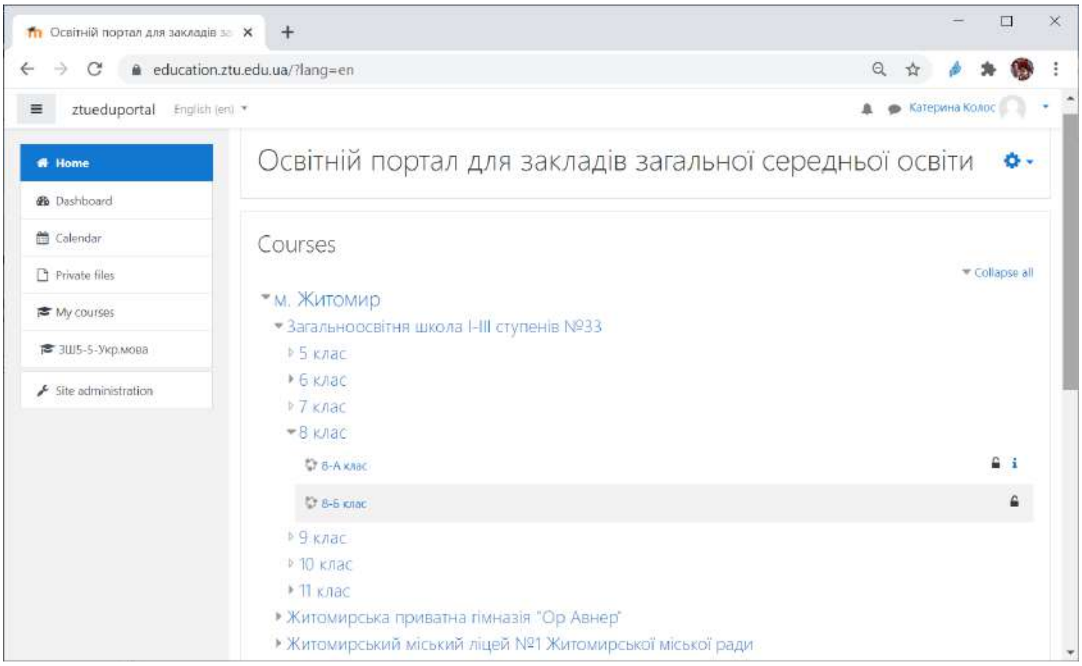

Figure 5: The structure of the "Educational portal for general secondary education institutions".

- Berezivska secondary school of I–II degrees;
- Velykovolytska secondary school of I–II degrees of Novograd-Volynsk district;
- Zholobnenska secondary school of I–III degrees;
- Ivankivtsi secondary school of I–III degrees of the Department of Youth Education and Sports of Semenivka village council.

• Khoroshiv district:
  - Budo-Ryzhanska secondary school of I–III degrees;
  - Chervonohranitnyanska secondary school of I–II degrees.

• Vinnytsia region:
  - Tomashpil secondary school of I–III degrees – gymnasium;
  - Makhnovskaya secondary school of I–III degrees.

Besides on the basis of this portal the State University "Zhytomyr Polytechnic" organized distance training of pedagogical and scientific-pedagogical workers within the course "The organization of mass distance learning during the quarantine" (108 hours). To register for this course you need to fill in an electronic form: https://forms.gle/MrKTtMwfziQ9hyw38.

Thus, within the definite course from October 5, 2020 to January 5, 2021 at the State University "Zhytomyr Polytechnic" 31 people improved their skills: 8 teachers of general secondary education (Zhytomyr local lyceum No. 1, Makhnovskaya Secondary School of I–III degrees of Vinnytsia Kozyatyn district, Velykovylytsia Secondary School of I–II degrees of Lyubar village council, Berdychiv education complex No. 4, Zhytomyr Technological College) and also 13 pedagogical and scientific-pedagogical employees of higher educational establishments (Municipal institution "Zhytomyr Regional Institute of Postgraduate Pedagogical Education" of Zhytomyr Regional Council, Zhytomyr State University named after Ivan Franko).

The training was carried out according to a special professional (certificated) program of professional development of pedagogical and scientific-pedagogical workers (tutors) taking to the consideration the organization of mass distance learning during the quarantine, the following topics were studied within this program:

1. Distance learning: relevance, features and principles of the construction, ways of development and scope.
2. The current state of distance learning in educational institutions of Ukraine.
3. Means of organization of distance learning.
4. Comparative analysis of distance learning plat-

forms.

5. Moodle system as a means of effective mass distance learning.
6. The development of the structure of the distance course.
7. Designing of the distance course.
8. Informational content of the distance course.
9. The development of distance course design.
10. Monitoring system of distance learning quality.
11. A tutor as an organizer and a leader of the distance course.
12. A student (listener) is the main person of distance learning.
13. The practice of developing and using a distance course on the Moodle platform.
14. The organization of educational activities in a computer-oriented educational environment of an educational institution.

After a successful training, all the participants received the certificate of professional development (figure 6).

Figure 6: The certificate of professional development according to the special professional (certificate) program of professional development for pedagogical and scientific-pedagogical workers (tutors) as for the organization of distance learning during the quarantine.

3 CONCLUSIONS AND PROSPECTS OF FURTHER RESEARCH

Thus, during the research it was found out that only 2% of teachers in Zhytomyr region had organized the system of distance learning for students, and 2% of respondents partially used distance learning technologies. At the same time, 96% of respondents carry out regular distance learning, among them 89% of teachers have introduced this form of education only since March 12, 2020 (since the introduction of the quarantine throughout Ukraine).

83% of teachers have the necessary technical support, but the biggest problem for distance learning is the lack of high-speed Internet access.

At the same time, for the implementation of distance learning, each teacher of Zhytomyr region uses only those software means which he knows and can use to implement the planned activities during distance learning.

As we know, only 59% of pedagogical workers use special distance learning platforms for the implementation of distance learning in general secondary education institutions nowadays, in particular: 37% – Google Classroom, 20% – "My Class", 2% – Moodle. Each of these platforms to some extent contains the necessary items for the implementation of the digital learning process. This led to the analysis of these platforms according to pre-established criteria and their indicators. In general, according to all the criteria for selecting distance learning platforms for general secondary education institutions, the numeral value of the level of manifestation in Moodle is the highest, so it indicates the significant advantages of the Moodle platform and the preference of its use in general secondary education institutions.

To use the Moodle platform, it is necessary to download it to the servers of the educational institution. However, most of educational institutions do not currently have the technical and financial capacity to do it. So, on the basis of the State University "Zhytomyr Polytechnic" on the Moodle platform the electronic resource "Educational portal for general secondary education institutions" (http://education.ztu.edu.ua/) was developed and it can be used by any educational institution.

The created technology of organization of mass distance learning for students of general secondary education provides a clear, logical and systematic combination of: the necessary means for the organization of distance learning; the usage of the definite electronic educational resource; the main components and structure of the distance course which contributes to the creation of conditions for learning in activities and collaboration; and also functions and competencies of the tutor, that is really necessary and important for the effective implementation and realization of distance learning.

Some further research is compulsory to identify the methodological features of the implementation of mass distance learning for students of general secondary education during the quarantine.

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CoCalc Tools as a Means of Open Science and Its Didactic Potential in the Educational Process

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Abstract: The article covers the questions of expedient CoCalc environment use as an integrator of services that can be used during different kinds of learning activities. Research goal is to identify the structural elements of the CoCalc environment, which are suitable for informatics and mathematical disciplines learning within the context of open science. Research objectives: a) consider the structure of the CoCalc environment kernel; b) highlight the structural elements that may be used in informatics and mathematical disciplines learning, and c) explore the prospects of their use. The object of research is the computer-oriented study of informatics and mathematical disciplines. The subject of research is the use structural elements of the CoCalc environment in informatics and mathematical disciplines learning. Research methods used: CoCalc environment analysis, comparison of its structural elements and their generalization according to informatics and mathematical disciplines. In the work analyzed, generalization and systematization of the major structural elements of the cluster CoCalc, reviewed the characteristics of items that can be used in the informatics and mathematical disciplines study. Results of the research will be used to improve methods of computer-based informatics and mathematical disciplines learning.

1 INTRODUCTION

Even before Computer Science disciplines studying, the programming basics may be taught directly within other courses. This is particularly true in the case of practically used methods and concepts. It may be considered as one of the ways to integrate practical programming exercises into other courses. We mean focused on the conceptual level rather than pure programming exercises, so that students learn more about specific computational methods and concepts. It is desirable that in the process of computer science learning one of the leading places was given to students' cooperative problem solving that will allow students to learn from each other and all together. As for collective structure, universal access is a key principle for learning in a modern higher education institution (HEI). After all, universal access is one of the principles of open education and open science, which is now being widely implemented in higher education in Ukraine. Solving together the same problem creates an atmosphere in which joint learning is an integral part of everyday practice in the learning environment.

Also, students, researchers, and teachers are subjects of the same information environment; they are equal community members (users) without a certain hierarchical structure. However, in reality there is a strict formal hierarchy in modern universities. Therefore, the question of the relationship between information environment users is quite topical. Because the difference between teachers and students is in fact quite clear, management in the digital environment is related to a structural hierarchy. Lecturers have not only to teach the content of their courses. Their task is also to maintain the existing configuration of the information environment (at least in terms of content) as well as to advise students in case of technical problems. However, it should be noted that in the digital environment, relationships unite all users: students, teachers, and researchers (Klaßmann et al., 2020).

There are another two problems in interdisciplinary relationships. First, social sciences and nat-

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ural sciences students have to put in a great deal of effort while perceiving information literacy material and have some difficulties in performing computational tasks. Humanities students often demonstrate a certain distance in the perception of computational approaches in general. Second, the variety of computing systems, methods, and concepts complicates the transparency, comparison, reproducibility, and transmission of results. Moreover, taking into account such a variety of calculation services, it is almost impossible to develop uniform methodological teaching standards. Therefore, not only information and communication technologies (ICT) courses are needed, but also it is necessary to integrate educational computer systems and research support systems (specialized, for scientists). This approach will help to strengthen the scientific component of students training not only in the humanities but also in technical specialties. In addition, such an integrative mechanism should promote the development of the students and researchers community within a single information space. The single digital environment meets the objectives and offers such integrating tools.

Science is a joint activity by definition. Research is usually conducted by several scientists working together, and this idea has been constantly confirmed in recent years. Moreover, experiments are increasingly being conducted in cloud services or with the use of cloud platforms, which involves the use of appropriate tools to support experimental activities. Workflow management systems and scenario-based tools are popular ways to conduct experiments, but these tools do not always support the idea of collaboration between a group of scientists. Even solutions aimed at collaborative experiments do not always meet the needs of users. Cloud service tools often focus on computing, but collaborating within a single environment is usually underestimated. Even if a certain cloud-oriented environment supports a work or learning management function, the group work is not considered enough in the framework of solving a specific pedagogical problem. Our research therefore was aimed primarily at the study of available tools for students' group tasks performing, joint research, and open access to research results. An experimental research carried out by a group of students, scientists and teachers is rather a challenge of today. There is an urgent need to identify every aspect of the collaboration between a group of students, faculty, and researchers. The analysis should be based on the study of current problems in the area from this aspect. In particular, the evidence in the following paragraphs suggests that the solution to some outlined problems is possible through the use of cloud service tools as a means of open science.

SageMath is an open-source computer algebra system. It has been used in most research on issues related to algebra and geometry. However, open-source cloud service has improved in recent years, and now it supports collaboration, the use of Python, R, Jupyter, LaTeX etc. Moreover, the CoCalc cloud service allows teachers to customize the LMS environment. Programming, the use of LaTeX, simulation – these are new skills in mathematics, and such environments contribute to their development (Martines, 2020).

2 ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

Klaßmann et al. (Klaßmann et al., 2020) presents a separate case study on the evolution of the digital learning environment and research at the Department of Musicology, University of Cologne. It covers 14 seminars from 2016 to 2020. In particular, the study examines the development of technological configuration as a digital environment and a curriculum development, which consists of educational practice in digital literacy and contains interdisciplinary links (Klaßmann et al., 2020).

de Assis Zampirolli et al. (de Assis Zampirolli et al., 2019) studied MEGUA (Mathematics Exercise Generator, Universidadede Aveiro) 2 – open source software that allows one to create data banks of parameterized questions with their corresponding answers in LaTeX. It works with the mathematical software CoCalc, which uses the Python programming language (de Assis Zampirolli et al., 2019). Data banks of questions are called "Books" and are built with PDFLatex (for printing) or HTML and MathJAX (for web publications) (de Assis Zampirolli et al., 2019). The development of the issue, in fact, takes place directly using the CoCalc toolkit. This process consists of three steps:

1) on a new sheet, a cell is created to import the entire MEGUA library and open / create a database to store questions;
2) the question code is being typed into another cell, which consists of LaTeX text and Python code. The LaTeX block is divided into sections (cataloging and description of the exercise), "% of the problem" (name and question) and "% of the answer" (its solution);
3) CoCalc complements the part of the computation that contains two functions: it generates random

values for the operator, calculates the correct solution and generates other multiple choices.

This cell yields two files: one in PDF format and another in text format (de Assis Zampirolli et al., 2019; Jandre et al., 2020).

There is also a resource for adding parameterized graphs to tasks, but MEGUA is not equipped with automatic correction of printable copies of questions, a function for rating hundreds of users.

The problem of developing a curriculum for courses in the study of operations has been carried out by Vlasenko et al. (Vlasenko et al., 2020). The research focuses on the implementation of cloud computing for solving optimization problems. The study (Vlasenko et al., 2020) confirms the appropriateness of using the CoCalc cloud environment in student teaching.

Bobyliev and Vihrova (Bobyliev and Vihrova, 2021) analyzed the experience of implementing courses in Calculus and History of Mathematics for future mathematics teachers in the learning management system of Kryvyi Rih State Pedagogical University. There is a block-modular approach to creating courses, which allows not only to structure the process of online fundamental mathematical subjects studying, but also to control the students' speed of content mastering and the depth of knowledge. There are examples of laboratory classes on the Calculus taken by by students independently in the CoCalc system of computer mathematics.

Gavrilyuk (Gavrilyuk, 2020) outlines the problems of using cloud services under the quarantine conditions. The scientist considered the possibilities of using cloud technologies for distance learning under precautionary measures, in particular, a key place among cloud services is occupied by CoCalc. An overview of cloud services that may be used to study Mathematics and Statistics related disciplines as well as their brief characteristics is offered.

The aim of the study is to identify the structural elements of the CoCalc environment, that it is appropriate to use in the educational process in the context of open science.

3 RESULTS

CoCalc (**Co**llaborative **Calc**ulation and Data Science; cocalc.com) is a virtual online workspace (cloud-based environment) for calculations, research, authoring documents in collaboration mode.

The learning and scientific activities in the CoCalc environment involve working on a project. The elements of a project are folders and files in different formats.

It is through the project files that the student and/or scientist accesses the main components of CoCalc explicitly (figure 1) or through an "intermediary" (file type "X11 desktop", figure 2).

According to CoCalc's statistics over the last month, the most popular environment instrumental and applied components are Jupyter Notebooks, Sage Worksheets, LaTeX Documents and R Markdown Documents.

The popularity of Jupyter Notebooks is obvious. Because it is on Jupyter Notebooks that you can modeling (calculate, programming, etc.), with the functionality of SageMath or Python or R or Julia.

Before talking about the already popular tools (SageMath, Python, R, LaTeX), let's focus on the latter mentioned, Julia.

Julia is a high-level, high-performance programming language with dynamic typing for mathematical calculations. The syntax is similar to the matlab family, the language is written in C, C++ and Scheme, it is possible to call C libraries.

Julia was designed from the beginning for high performance. Julia programs compile for efficient native code for multiple platforms via LLVM.

Julia plays dynamically, is a scripting language and has good support for interactive use.

Playable environments make it possible to play the same Julia environment every time, on different platforms, with pre-built binaries.

Julia uses multiple sending as a paradigm that facilitates the expression of many object-oriented and functional programming patterns. Provides asynchronous I/O, metaprogramming, debugging, logging, profiling, package manager, and more. You can create entire programs and microservices in Julia.

Julia is an open source project with more than 1,000 authors. It is provided under MIT.

But first of the stages in the development of the CoCalc is a web Computer Mathematical System (web-CMS) *SageMath*.

SageMath is a free open-source mathematics software system based on many existing open-source mathematical packages – FLINT, GAP, Matplotlib, Maxima, NLTK, Numpy, Pandas, Scikit Learn, Scipy, Statsmodels, SymPy, and many others. They can be accessed using a generalised language based on Python, or directly through interfaces or shells.

The available web-CMS tools of SageMath version 4.6 (the latest version before the advent of CoCalc, even earlier than SageMathCloud) were not sufficient to organize all types of learning activities under distance learning or its elements. It was necessary either to organize training or with the involve-

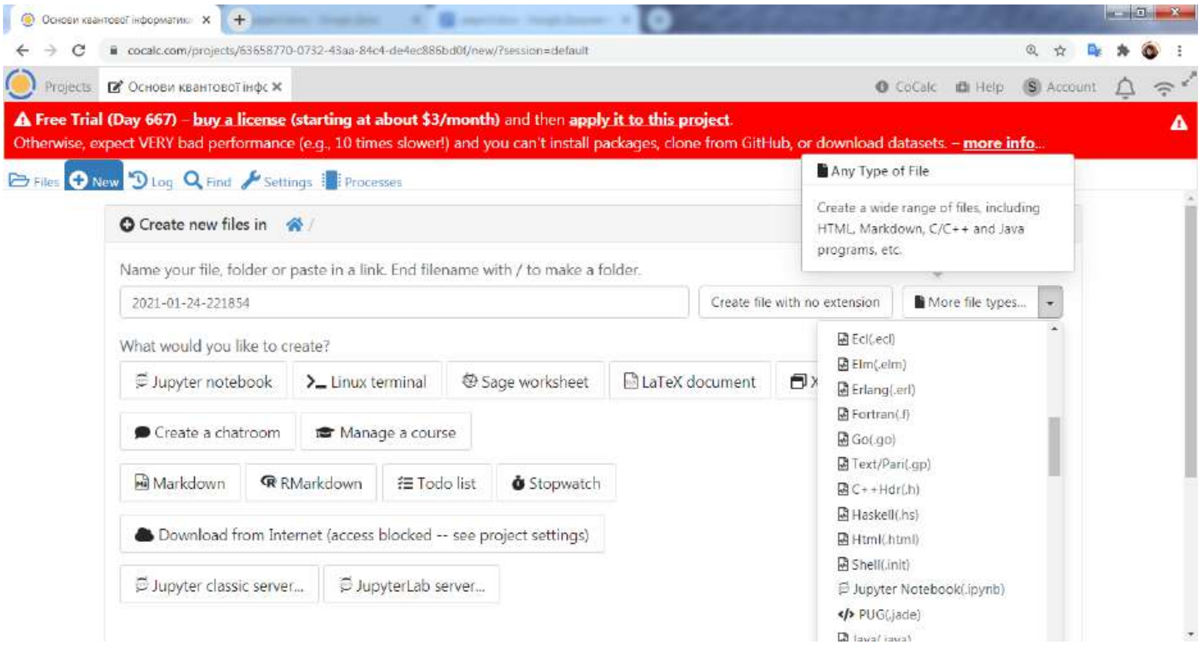

Figure 1: Page to create a new project file.

ment of two systems – web-CMS SageMath and any system to support distance learning, such as Moodle, or to integrate them. The first method proved to be inconvenient for neither teachers nor students, the second method – continues to be widely used (Shokaliuk et al., 2020), but it, with the advent and improvement of CoCalc, may lose relevance.

Since 2014, more than 80 students have completed the courses “Computer Technologies in Research” and “Computer Mathematics” for future computer science teachers with the additional qualification “applied programmer”. The SageMath toolkit in CoCalc became especially popular with the advent of the ability to work on interactive Jupyter Notebooks instead of Sage Worksheets (Markova et al., 2018). While the latter has the advantage of being able to work simultaneously (within one sheet) with different mathematical applications.

In addition, future teachers of mathematics and computer science were offered to master the tools of SageMath in CoCalc within the optional course “Using SageMathCloud in learning mathematics” (by Maiia V. Marienko), the course “Numerical Methods / Methods of Computing / Computational Mathematics”, “Discrete Mathematics”, “Operations Research”, “Mathematical Programming”, as well as to perform independent work on the courses “Linear Algebra and Numerical Systems”, “Analytical and Differential Geometry”, “Calculus”, “Probability Theory and Mathematical Statistics”.

The mathematical packages FLINT, GAP, Matplotlib, Maxima, NLTK, Numpy, Pandas, Scikit Learn, R, Scipy, Statsmodels, SymPy, TensorFlow are known as members of the *Python Scientific Computing Ecosystem* or more simply *Scientific Python* because they provides data processing (modeling, experiment control) and visualize results for quick analysis with high-quality metrics for reports or publications.

Among the tools mentioned, the packages *TensorFlow* and *R* are of particular note.

TensorFlow is a comprehensive open source platform for machine learning. It has a comprehensive flexible ecosystem of community tools, libraries, and resources that allows researchers to advance the latest advances in machine learning, and developers can easily create and deploy machine-based applications.

R is an integrated suite of software facilities for data manipulation, calculation and graphical display. Among other things it has

- an effective data handling and storage facility;
- a suite of operators for calculations on arrays, in particular matrices;
- a large, coherent, integrated collection of intermediate tools for data analysis;
- graphical facilities for data analysis and display either directly at the computer or on hardcopy;
- a well developed, simple and effective programming language (called ‘S’) which includes conditionals, loops, user defined recursive functions and input and output facilities. (Indeed most

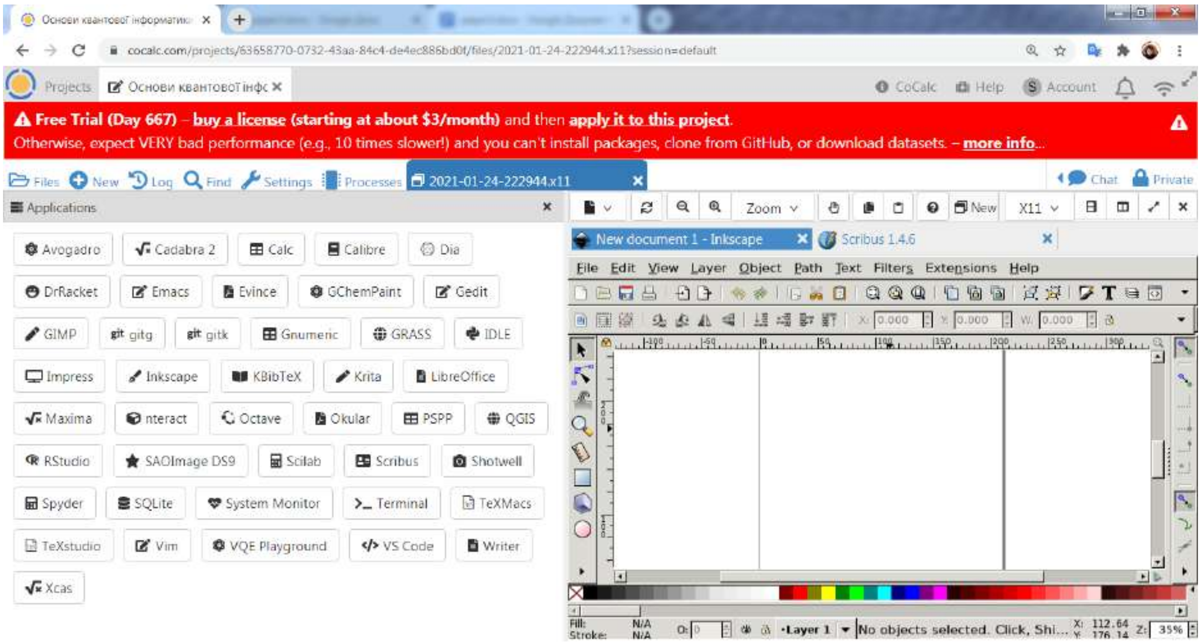

Figure 2: Page of a new file of type "X11 desktop".

Table 1: The main components (components, software) CoCalc: System software.

Type of software	Name of the software
Request and process user account information	accountsservice
FTP client	CFTP
VNC server	X11vnc
Archiver	7-ZIP, gzip, tar
Free command line utility for data compression	bzip2
Garbage collector	The Boehm-Demers-Weiser
Shell for GNU Screen and Tmux (application)	Byobu
Shell for Python GD library	gdmodule
Program for displaying a list of running processes	htop, ps
SageMath Notebook Server	SageMathNB
Operating System	Debian GNU/Linux

of the system supplied functions are themselves written in the S language.)

R is very powerful tool for newly developing methods of interactive data analysis. It has developed rapidly, and has been extended by a large collection of packages.

Since September 2018, almost 50 PhD candidates have been involved with the R toolkit in CoCalc and have successfully completed the Modern Information and Communication Technology in Research course.

To support cumbersome scientific calculations, there is a need to reduce the computational delay. Edge computations adopt a decentralized model that brings cloud computing capabilities closer to the user equipment to reduce computational latency. There are two types of projects in CoCalc: "trial (free) projects" and "participating projects". Trial projects run on computers that share the same node with many other projects and system tasks. These nodes may also stop at any time, causing the current project to interrupt and restart.

Projects accepted by members are transferred to less loaded machines, which are reserved only for users who have purchased one of the proposed licenses (tariff plans). Those servers are not being restarted daily. The cluster is dynamically scaled to accommodate different numbers of member projects.

Work on members projects is much smoother because commands are executed faster with less delay, and heavy operations of the processor, memory and I/O work faster.

By default, free projects stop working after about

30 minutes of inactivity. This makes the calculations quite time-consuming.

There is an advanced license option to completely prevent downtime. Processes can still stop if they use too much memory, crash due to an exception, or or being restarted by the server on which they are running.

That is, for users who have purchased one of the proposed tariff plans, there are more opportunities to use edge calculations.

Also, it is possible to change the free tariff plan (default) Hub server by clicking “Reconnect” (figure 3). To some extent, this setting may also be considered as a practical use of edge computing (Chen et al., 2016).

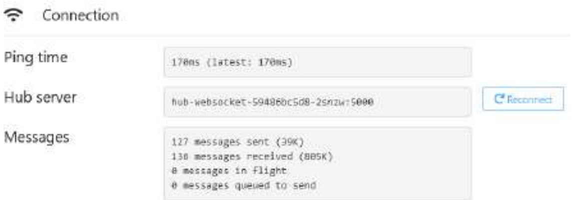

Figure 3: Pop-up settings “Connection”.

In addition, we should mention Big Data. The complexity arises from several aspects of the Big Data lifecycle, such as data collection, storage on cloud servers, data cleaning and integration. But edge computing solves this problem, which is an essential point for working with CoCalc.

CoCalc offers a wide collection of software environments and libraries (see tables 1-4).

A complete list of the current versions of CoCalc (1267 Python packages, 4472 R packages, 447 Julia libraries and more than 243sd files have been installed) can be obtained by using the command `$ sudo dpkg --get-selections`.

Detailed information on the specified in tables 1-4 and other CoCalc components (at the time of publication) can be obtained by direct link https://cocalc.com/help on the official website of the CoCalc project.

Implementation of research projects, term papers with the use of CoCalc involves two ways:

1. Using the individual tools presented in CoCalc.
2. Execution, writing and registration of results of educational and research work in CoCalc without involvement of auxiliary software.

At the same time, teachers and a group of students can be involved in the research project.

The IPython interpreter in the process of training future mathematics teachers can be used to develop dynamic models with semi-automatic / automatic demonstration modes.

The first way involves creating a model (models) of the phenomenon under study on a worksheet using standard controls, HTML tags, LaTeX commands and using CSS.

The disadvantages of this use are that in the process of registration of the obtained results have to involve other software: text editor, software for creating presentations, video editor (if necessary). As a result, only a certain point of the research work was performed using the CoCalc toolkit. In addition, in the process of presenting scientific findings, the student will have to demonstrate to their colleagues in addition to the presentation of the developed model using a browser (or video editor). This can be avoided by using CoCalc tools not only to perform the research part of a particular job. Therefore, it is better to use the built-in LaTeX editor as a CoCalc tool.

LaTeX is a high-quality text document program.

LaTeX is a TeX-based macrosystem that aims to simplify its use and automate many common formatting tasks. This is the de facto standard for academic journals and books, and it offers one of the best free typography programs it has to offer.

Performing a term paper or a thesis in the LaTeX editor, the student has the opportunity to print it, preformed on the basis of a resource such as tex PDF-document.

That is, at the same time there is a process of registration of the obtained results, calculations, presentation and presentation of the main provisions of the study (using the presentation developed in the LaTeX editor) and demonstration of the created model. The student does not need to include additional software to perform, design or present the results, because all the work is completely unified within one cloud service – CoCalc.

```
\documentclass{article}
\usepackage[a5paper]{geometry}
\usepackage[utf8]{inputenc}
\usepackage[ukrainian]{babel}
\usepackage{sagetex}
\title{Sharing Sage and LaTeX}
\author{M. V. Popel}
\date {13 January 2015 year}
\begin{document}
\maketitle
The easiest way to embed the results of
Sage commands in the tutorials created
in LaTeX is to use the sage and
sageplot tags:"
a) finding the derivative:
$(x^3)'=$$\sage{diff(x^3,x)}$
b) plotting:
\sageplot{plot(sin(x),-pi,pi)}
\end{document}
```

Table 2: CoCalc main components: General purpose application software.

Type of software	Name of the software
Analog screen for graphics programs	Xpra
Database of combinatorial graphs	Graphs
Library for rasterization of fonts and operations on them	FreeType
Library for working with raster graphics in PNG format	Libpng
GNOME tooltip browser	Yelp
File management and collaboration system	Mercurial
Electronic dictionary (thesaurus)	WordNet
Image viewer	GPicView
Interactive editor and macro support	Prerex
Programs for comparing the contents of text files and directories	Meld, diff
Services for reading e-books	Calibre, Evince
Document processing system in HTML, LaTeX or XML document formats	Docutils
Database management systems	RethinkDB, sqlite3
Text editors	GNU Emacs, Vim, nano, mcedit, AbiWord
Utility for finding differences between files	GNU patch
Cloud file storage	Dropbox

You can of course offer an alternative to CoCalc – Jupyterhub and Zoom. However, they do not include the ability to synchronize with other community members in a text file, although Zoom has a basic real-time chat feature. Of course, you can offer to integrate the Markdown hypertext into the configuration by using the Jupyter Notebook, which seemed to be the ideal solution to enable collaboration in a browser-based text document in real time using Zoom, for example in workshops. In addition, HackMD Markdown files will be available to students at any time and will be used for notes during the workshop. In this way, you can create joint documents that implement synchronous and asynchronous discussions. In addition, HackMD will provide tools for documenting group work sessions so that it is easy to share with other users. In this way, you can create templates for courses that will be used later for notes, discussion of seminar topics outside the classroom. Currently, Jupyterlab does not allow real-time collaboration on real-time collaboration due to technical limitations.

CoCalc offers shared computing capabilities to small groups of users. It also includes basic chat and video conferencing features. CoCalc toolkit supports student projects and group assignments that require synchronous collaboration in computer science and math. Because CoCalc is also based on the Jupyter Notebook, integration with individual workspaces will be seamless, as users in the same group can easily transfer individual files between CoCalc to both the shared workspace and their own, private instance of Jupyterlab. Using the advanced configuration with Zoom, HackMD and CoCalc, seminars can be organized completely remotely (Klaßmann et al., 2020).

Overall, this configuration is a good starting point for the further evolution of the digital environment and the management of a group of students to increase digital literacy in interdisciplinary research and the teaching of computer science and mathematics. To assess the cloud environment, it is necessary to take into account both the student's opportunities and interaction with them, as well as the success in achieving interdisciplinary learning goals and the level of discussion of the content achieved in seminars. CoCalc cloud service can be recommended to groups of students of all academic levels, from bachelor to doctoral and teachers of various fields of science. The use of a single cloud platform has certain advantages: it will help to form and hold regular meetings to discuss modern computational approaches in interdisciplinary research. This creates a digital environment for developing students and researchers that goes beyond weekly seminars. From the point of view of teaching, seminars conducted in one case study will confirm the potential of a common information environment for teaching computational interdisciplinary research. Thus, students with limited programming experience or no previous programming experience during distance learning workshops will be able to fully learn the basics of Python programming and gain skills in discussing and implementing high-level computational models (Klaßmann et al., 2020).

The evolution of the configuration of the digital environment demonstrates clear progress, which is closely linked to the requirements of pedagogical and methodological practices within the developing free

Table 3: CoCalc main components: Special purpose application software.

Type of software	Name of the software
Automatic grid generator for geometric constructions	Gmsh
Software package for algebraic, geometric and combinatorial problems on linear spaces	4ti2
Library for performing problems in number theory	FLINT
Library for dynamic work with images	GD Graphics Library (GD)
Library for processing video and audio files	Ffmpeg
Library for working with graphs and other network structures	NetworkX
Library for solving linear programming problems	GLPK
Library for solving convex programming problems	CVXOPT
Library designed for applied and scientific mathematical calculations	GNU Scientific Library (GSL)
Libraries for determining and calculating elliptic curves defined over a field of rational numbers	eclib
Vector graphic editor	Inkscape
Sage versions	Sage.7, Sage.8, Sage.9, Sage.10
Client for Git repository	SparkleShare
Mathematical library	Cephes
Mathematical library for performing actions on complex numbers	GNU MPC
A set of libraries that extend the functionality of C++	Boost
SageTeX package extension	SageMathTeX
Software package for generating three-dimensional models	GenModel
Software package for scientific calculations	Scilab
Software packages for building phylogenetic trees	Phylip
System for mathematical calculations	GNU Octave
Computer algebra systems	Gias/Xcas, Axiom, GAP
Computer mathematics system	Maxima

economic system, students and researchers. Thus, the resulting configuration for the introduction of computational thinking and digital literacy consists of the following tools that support the necessary functions in a single digital environment:

- Jupyter Notebook, which is serviced through Jupyterhub, will provide a basic environment for notes, programming and working with computational methods and concepts without the need for local installation and maintenance.
- GitHub, GitHub Pages, and GitHub Classroom will be used to track file versions, create a course website as an alternative communication channel, and support the logistics of issuing and submitting course assignments.
- Zoom will provide a tool for interactive synchronous social communication in distance and face-to-face learning.
- HackMD is used for synchronous co-writing of hypertext documents.
- CoCalc provides collaborative real-time programming based on the Jupyter Notebook.

4 DISCUSSION

The roadmap for Ukraine's integration into the European Research Area (ERA-UA) has been approved by the decision of the Ministry of Education and Science of Ukraine No. 3/1-7 on March 22, 2018. Priority 5 contains a sub-item, which indicates the further directions of open science development in Ukraine. Open science means revealing a research process by publishing all its results as well as details on how they have been achieved and making them publicly available on the Internet.

The practical use of the open science paradigm is (Shyshkina, 2018): presentation of educational materials in open access (data, program of the event, abstracts, minutes of meetings, didactic materials, data analysis files); open access materials publication; free distribution and dissemination of educational and scientific materials and data (for example, uploading content to an open repository).

If we consider the principles of open science, then, according to Shyshkina (Shyshkina, 2018), it means (Shokaliuk et al., 2020):

Table 4: CoCalc main components: Software tools.

Type of software	**Name of the software**
Interactive shell for programming	Jupyter Notebook
Python programming language interpreters	Python 2.x, Python 3.x, Python (Anaconda)
C ++ programming language compilers	C++
Interpreters	CPython, Java, Perl, bash
Compilers	Mono, Embeddable Common Lisp
Functional programming environments	DrRacket, MIT/GNU Scheme
Environment for statistical calculations, analysis and presentation of data in graphical form	R

- open access to scientific sources;
- open access to electronic resources used during the study;
- free access to data arrays obtained during a pedagogical experiment;
- open e-infrastructures.

A common example of open source is the large number of open source virtual learning environments used in the academic environment. The most striking example is Moodle due to its widespread use in educational institutions (Mintii et al., 2019; Polhun et al., 2021).

As a consequence, the introduction of open science norms in Ukraine should lead to greater exchange, accountability, reproducibility and reliability of scientific materials and affect the learning process as a whole. In the process of studying domestic and foreign experience, the following advantages of using cloud services for mathematical purposes were identified: resource savings; access mobility; flexibility.

Cloud platforms and services engaging with the educational process leads to the emergence and development of education and research organization forms focused on joint educational activities, creating more opportunities for educational and research projects (Merzlykin et al., 2017; Popel et al., 2017; Lovianova et al., 2019). Methods and approaches of open science have a significant impact on the educational process. Given the above advantages of cloud-based tools in the mathematical disciplines teaching, as well as the prospects of the CoCalc cloud service implementation in the educational process, the study considers this service to be a potential cloud component of open science.

CoCalc is a cloud service, a virtual workspace for computing, research, collaboration and document creation (Jandre et al., 2020), which contains a cloud storage where scientists may share files with their colleagues. These include Jupyter sheets, where multiple scientists may edit scripts in real time.

CoCalc (Jandre et al., 2020) supports query, detection and visualization subphases. This allows scientists to query the results of the experiment and its history, among other data. Users may also visualize results using Jupyter sheets and libraries, such as matplotlib. They may also use chats to discuss an experiment and its stages.

In this cloud service (Jandre et al., 2020) the whole experimental environment is based on the principle of cloud operation. All changes are made directly in the cloud and synchronized with the user's browser via the Internet, that is to say, no blocking occurs.

CoCalc (Jandre et al., 2020) allows one to share a wide variety of files, including scripts in different programming languages. The cloud service toolkit allows you to share documentation that can help scientists understand what has been done in the experiment and help them make better use of shared data and scenarios.

The cloud service (Jandre et al., 2020) makes it possible to store performed by scientists interaction in a journal (chronology), but it resembles more unstructured information that is difficult to reproduce.

Although the cloud service is absolutely ready for use in research (Jandre et al., 2020), it requires a stable Internet connection to work. Working with the service is possible directly through the browser, which may cause some difficulties when replacing the workspace, tools and development environments to which the scientist is accustomed. You may run code from the CoCalc environment, but this method is different from running files from a scientist's device. There are some restrictions on using a free cloud service account. Another problem worth mentioning is that CoCalc does not properly capture all stages of the experiment. It provides features such as “time travel” and “log” that allow users to see the history of file changes and activity of project participants. But these data cannot be fully detailed so will be insufficient to guarantee the reproducibility of the experiment.

It may be concluded that CoCalc meets all the principles of open science. And CoCalc tools may be considered to be open science tools that have didactic potential in the learning process.

5 CONCLUSIONS

The given chronology clearly demonstrates creation and adaptation of the digital environment on the basis of particular needs and practical tasks of group of students, teachers and researchers in interdisciplinary researches and educational process. As the digital environment is constantly evolving, research cannot be considered exhaustive. We intend to integrate the configuration of CoCalc and the curricula of individual disciplines for a deeper training material understanding and to expand the means of professional competencies forming of future specialists in various fields of education and science. CoCalc tools enhance students' ability to organize and perform teamwork by implementing a joint project task. Thus, if the cloud service is used, the indicators of scientific research improve, the educational process becomes more open, appropriate to human needs and content relevant.

Given the growing popularity of free software and a wide range of CoCalc applications and services, it should be noted that there is need to develop teaching materials for Computer Science and Mathematics.

The use of cloud services leads to the emergence and development of learning forms, focused on joint learning activities on the Internet. Cloud services should be used in Mathematics teachers training as a means of: communication; cooperation; data storage and processing, which should be the subject of further research. It is advisable to focus further research on the dissemination of open science approaches to Mathematics teachers training process.

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The Method of Teaching Graphic 3D Reconstruction of Architectural Objects for Future IT Specialists

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Abstract: The method of teaching future IT specialists modern 3D-technologies of graphic reconstruction of architectural objects has been developed and tested in the educational process. The peculiarity of the implementation of the stages of the proposed methodology of graphic reconstruction is exemplified through building the model of the Parochial Cathedral of St. Mary of the Perpetual Assistance of the 1950s. Sequence and content of operations for analytical and design engineering stage are substantiated. After analysing and assessing the most popular specialized software means, the 3DS Max environment is chosen to build a three-dimensional model. The complex method of graphic reconstruction of historical architectural objects is proposed. This method consists in constructing a three-dimensional model of an object, based on a combination of a design technique using modern 3D technologies and methods for analysing archival descriptive information and data on a set of images using parallax estimation of a data array of stereopairs of images. The cathedral model is built on the basis of archive photographs and drafts. Reconstruction of spacious configuration of the objects is based on parallax assessment of images. There are described methods of implementing modelling by 3DS Max tools and preparing the model for 3D printing in Cura. Substantiated the effectiveness of the proposed training method to teaching future IT specialists of 3D technologies of graphic reconstruction. This method contributes to the formation of students' system of theoretical and practical knowledge on the design of buildings and structures using modern digital technologies for their graphic reconstruction it has been proved.

1 PROBLEM STATEMENT

The current level and pace of development of information technology prompts a new look at the essence and methodology of training IT specialists, whose activities are related to the design of environmental objects. In connection with the rapid development and introduction of digital technologies in all branches of human activity, 3D technologies are becoming an important component of modern education. Now there are new opportunities for their use in the graphic reconstruction of architectural objects and are constantly progressing.

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3D graphics allows you to create spatial models of various objects, repeating their geometric shapes and imitating the texture of materials (Kozak, 2016). It is impossible to replace 3D models in all spheres of human activity including industry, medicine, architecture, construction, design, education, cinema, etc. Using 3D technologies for design and graphic reconstruction of architectural objects, we can recreate architectural objects that have been destroyed (Seidametova et al., 2021). This allows you to analyse the features of the architecture, to recreate the structure of the object and to correct its model with a high degree of realism. The importance of researching this issue is confirmed in the "Declaration of Cooperation on advancing the digitisation of cultural heritage", which was signed by 27 European countries (Commission européenne, 2019b). In particular, the European Commission's expert group on the digitization of cultural heritage has developed general guidelines for a comprehensive, holistic 3D documentation

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of European cultural heritage sites (Commission européenne, 2019a).

3D model design enables assessing technical and physical properties of a modelled object before creating a real sample. The methods of studying a model allow analysing its size, material and package contents.

The concept of an object or a project is mainly exemplified by videos or pictures based on 3D graphics. This sets constraints on viewing, as static pictures cannot enable plot change or detailed examination.

Modern potential of 3D graphics and computer hardware capacity enable processing complex scenes on-line without reducing rendering speed and quality. This has evoked professionals' interest to 3D visualization in various activity spheres.

In architecture and bridge engineering, wider application is given to virtual buildings with inside walks and virtual cities. Photorealistic reconstruction of objects makes it possible to work with object models in museum, reconstruction and commercial projects and while studying (Borodkin, 2015).

Maintaining and promulgation of cultural heritage are essential for modern society. Development of computers and 3D graphic tools enables preserving cultural achievements not only as pictures or photographs but also as models in their original form or as electronic replicas of real-life objects (Rumyantsev et al., 2011).

A great number of architectural monuments have disappeared without any sizes, drafts or photographs left. For such historical objects, graphic reconstruction as a scientific study is the only means of identifying the lost or destroyed architectural object of a certain time period. Graphical reconstruction of architectural historical heritage reflects the whole bulk of knowledge concerning it available to date (Rozhko, 2013).

In recent years, there have been numerous museums including the virtual ones with their exhibits being computerized objects. Museums of this kind enable obtaining detailed information on historical achievements, getting to know their origin and facilitating cultural development of society.

Therefore, the study of 3D technologies for the graphic reconstruction of architectural objects by future IT specialists is one of the topical areas of research into the problem of their professional training.

2 LITERATURE REVIEW

Nowadays, innovative technologies of 3D graphics, modeling and design enable restoring lost historical objects. Analysis of the degree of investigation reveals only certain aspects of 3D modelling covered in modern scientific literature.

A significant amount of scientific and pedagogical research is devoted to the consideration of the problem of using 3D technologies in the process of training future IT specialists. Technologies for selecting software for 3D modelling and methods of working with them are described by Osadcha and Chemerys (Osadcha and Chemerys, 2017). The issues of 3D modeling in architectural design are revealed in (Borodkin, 2015; Rumyantsev et al., 2011; Rozhko, 2013).

3D modeling as a design and architecture tool is indirectly touched upon in (Danylenko, 2005).

Despite this, works devoted to the problems of theory and methods of engineering and graphic training of students (Bakum and Morozova, 2015; Lavrentieva et al., 2021). The issues of professional training of future IT specialists was examined in (Babkin et al., 2021; Ozhha, 2012; Osadchyi et al., 2019; Semerikov et al., 2020; Varava et al., 2021).

However, the problem of studying 3D technologies by future IT specialists has its own both theoretical and methodological features, since it requires consideration in the context of a specifically graphic type of activity. For the qualitative formation of students' practical skills in modelling and printing 3D objects, it is necessary to introduce the study of such technologies as an obligatory component of their educational process (Hevko et al., 2020b, 2021).

The features of creating and using 3D models of historical architectural objects in the educational process are considered in (Milkova et al., 2019; Maietti et al., 2019). The works (Butnariu et al., 2013; Kotsiubivska and Baranskyi, 2020; Riabokon, 2002) are devoted to the study of the capabilities of 3D modelling tools in the tasks of computer reconstruction of objects of historical and cultural heritage.

At the same time, it is worth noting that integral scientific approaches to the method of using 3D technologies in the graphic reconstruction of architectural objects, as a component of the professional training of future IT specialists, are not sufficiently disclosed.

Thus, analysis of the scientific literature makes it possible to draw conclusions about the need for further scientific research on 3D technologies for the graphic reconstruction of architectural objects and the development of appropriate guidelines for training future specialists.

The relevance of this problem made it possible to determine the aim of the paper – to reveal the effectiveness of the method of teaching future IT- specialists modern 3D technologies of graphic reconstruction of architectural objects.

The research object involves is the process of teaching 3D technologies for the graphic reconstruction of architectural objects in the preparation of future IT specialists on the example of creating and printing a 3D model of the Parochial Cathedral of St. Mary.

The novelty of the research – a comprehensive methodology for studying the graphic reconstruction of historical architectural objects has been proposed. This methodology consists in developing the skills of constructing a 3D model of an object based on design technologies according to image analysis using a parallax assessment of a stereopair data array of images of the objects under study.

3 RESULTS

3.1 Substantiation of Teaching Methods of 3D Technologies of Graphic Reconstruction

The experts of the Declaration on the Promotion of the Digitization of Cultural Heritage recommend that the skills of using 3D technologies be included as part of the basic knowledge of IT professionals regarding the restoration of cultural heritage (Commission européenne, 2019a). Graphic reconstruction professionals need to have the necessary knowledge and skills to design a project well, save raw data and 3D layouts. To solve this problem, an important condition is the development of training courses for studying 3D technologies in order to preserve cultural heritage or 3D technologies in general.

The skills of using 3D technologies for the graphic reconstruction of architectural objects is an important component for the professional training of future IT professionals who can develop practical skills in working with 3D technologies that are in demand in the modern labour market.

Therefore, on the basis of the research carried out, we propose a methodology of teaching graphic 3D reconstruction. The methodology provides the formation of a system of theoretical and practical knowledge of students for designing buildings and structures using modern digital technologies of graphic reconstruction.

The proposed methodology is based on the following principles: systematic and consistent, accessibility, clarity, connection between theory and practice, a combination of the individual and the collective.

The principle of systematicity and consistency consists in the formation of knowledge, skills and abilities systematically, in order that each lesson has little interconnection, and new knowledge is based on previously acquired knowledge and creates the foundation for the following knowledge. In each topic, the lesson gradually increases the complexity of the material. The logical completion of the course is the implementation of the project in groups, with the help of which students will improve and consolidate their knowledge, and will be able to try themselves in teamwork.

The principle of accessibility is that the forms, methods and content correspond to the capabilities of students and their level of knowledge in this area. Therefore, students should already know what graphics are and learn how to build simple models, and only then start modelling complex objects.

The principle of clarity is applied directly in the classroom: to demonstrate how to build individual elements in the program and after a while we give students the task to reproduce it. Thus, we encourage them to be attentive in order to be able to complete tasks and thus develop interest in the course.

The principle of connection between theory and practice is implemented by students when performing laboratory work, or tasks of different types. This is preceded by the study of theory.

The last principle is the combination of the individual and the collective. It provides not only work that is performed individually, but also tasks that require group execution. It will help students exchange knowledge, listen to each other in order to complete the assignment efficiently.

Taking into account the correspondence of the set tasks, we consider it expedient to divide the method of graphic reconstruction of architectural objects by means of 3D technologies into the following main stages: analysis, construction, design, model printing (figure 1).

At the analysis stage, students collect the necessary data about the object and the necessary operations to build a 3D model. Solving such problems allows students to form analytical skills and a creative approach to the synthesis of objects based on the available information.

The construction of an object includes the process of modelling (creating a 3D model) and the process of animating (driving existing models or adding additional cameras and moving them along certain trajectories). At this stage, students develop engineering skills through the use of modern software tools and techniques for their use.

The design phase includes texturing and rendering. Solving design problems allows students to form

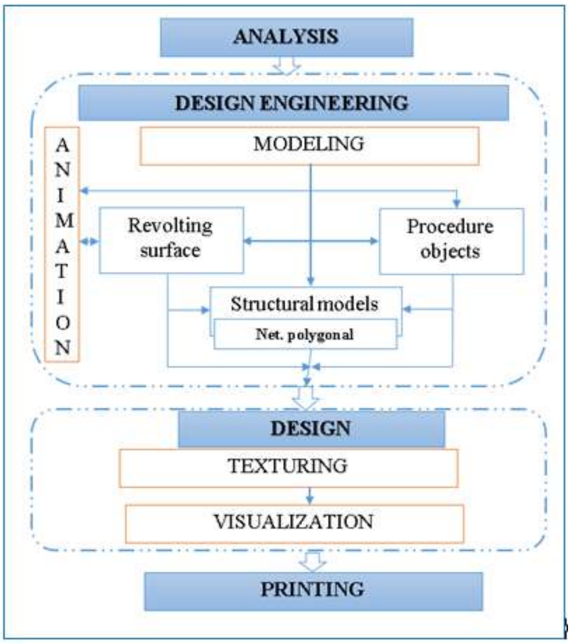

Figure 1: Stages of project development.

the ability to compose objects in compliance with the colour scheme, select materials and textures, choose light sources, change and adjust camera angles.

The final stage of the technique is the manufacture of a model using 3D printing. At this stage, students develop technological skills in working with modern equipment: setting the parameters of the 3D printing process, calibrating the printer table, selecting materials for printing.

Thus, we consider it expedient to reveal in detail the implementation of each of the stages using the example of creating a 3D model of the Parochial Cathedral and substantiate the effectiveness of the proposed method.

3.2 The Sequence and Content of the Analytical Stage of the Proposed Technique

3D modelling is a separate type of computer graphics, which incorporates necessary tools and techniques applied to building a model of an object in the 3D space. 3D modelling techniques of a graphic object include the following main cycles: the analytical cycle (collection of input materials; calculation of object sizes and parameters) and the modelling one (building a draft of an object form; accumulation, carving, stamping, etc.).

Nowadays, 3D modelling is used in almost all fields of human activity including advertising, marketing, industry, computer games, cinema, architecture, design and animation. 3D models of buildings and facilities are an integral part of modern design providing the basis for making object prototypes with maximum granularity.

Stages of building 3D models of monuments and landscapes are specific in their character depending on set tasks and software chosen. However, the most essential components of the methods are general for different modelling objects. While setting a task for modelling, it is necessary to determine the rate of granularity and realism of the end product (Krejdun, 2014). Realism of a model depends on selected materials for overlaying textures onto an object. Virtual 3D modelling for architectural buildings is based on solving the task of the efficient layout widespread in the theory of pattern recognition.

Nowadays, there are many software means of various parameters and applications in computer graphics. Choice of software primarily depends on the task set. After selecting functions and means required for solving the task, it is necessary to choose efficient software to build 3D models.

Architects and designers make good use of 3D graphics technologies because they are efficient and easy to use for project implementation. To select the required software environment, a survey was conducted among experts in this field and students who study the basics of 3D modelling. Based on the survey, the following software products are identified as the most popular: Blender, 3D Max, SweetHome 3D, SketchUpMake, Pro 100, FloorPlan 3D, ARCON 3D Architect, ArchiCAD, Maya, LUMION, Cinema 4d. It should be noted that the most appropriate is the use of environments SweetHome 3D, 3DS Max, FloorPlan 3D, ARCON 3D Architect, ArchiCAD in the architectural direction (Osadcha and Chemerys, 2017).

As our task is to build a model of an object, we should analyse the above-mentioned programmes to choose appropriate software. Parameters of evaluation quality are chosen according to ISO 9126:2001 Standard in which each characteristic is described by its several attributes (Danylenko, 2005). In this case, they include functionality, user-friendliness, efficiency, the programme interface and render quality (the final image after processing) as the most important parameter. As these criteria are not equivalent, importance factors are determined for each of them relevant to the set task (table 1).

Evaluation is performed in the system from 1 to 10 points for each parameter on the basis of working with similar programmes. So, evaluating the characteristics of software that would be advisable to use for graphic 3D reconstruction of architectural objects, we obtained the following rating results: FloorPlan 3D –

Table 1: Assessment parameters.

Parameter	Importance factor
Functionality	3
User-friendliness	2
Efficiency	2.5
Program interface	1.5
Render quality	4

44 points, ARCON 3D Architect – 50, SweetHome 3D – 80, ArchiCAD – 97, 3ds Max – 135 points.

Thus, according to the rating, it was determined that the most convenient and effective for graphic 3D reconstruction are 3ds Max and ArchiCAD, the work in which is convenient and efficient. However, the final result of the model of the final renders in the 3DS Max system is much better. Therefore, to create the model of the Cathedral, the 3DS Max environment was chosen, which has all the necessary tools for rendering high realistic quality.

Graphic reconstruction of lost or destroyed architectural objects is a specific type of activity aimed at studying these objects in order to restore their appearance as of the time of their existence by 3D graphics means being guided by the preserved documents, drafts or photographs (Borodkin, 2015; Rozhko, 2013).

Graphic reconstruction provides for absence of precise data on an object from a single data source. It is applied to restoring a lost appearance by means of graphic and document data through collecting and combining it from various sources. Graphic reconstruction being an activity is thought of as a set of operations including data collection, object investigation and fixation prior to modelling options of a destroyed architectural monument.

The Parochial Cathedral of St. Mary of the Perpetual Assistance of the 1950s (hereafter – the Parochial Cathedral) is one of the lost historical objects of Ternopil that decorated the city centre at the corner of Ruska and Mitskevich Streets (modern Shevchenko Boulevard). Photographs and drafts are basic data sources concerning the Cathedral.

The historical and architectural key plan of Ternopil indicates that "the majestic and delicate building in the neo-Gothic style was striking in its beauty and perfection. The slim tower-spire of 62m high was hovering over the city as if striving upward into the sky. It was even used as a fire tower built upon the project of the famous Lviv architect Professor Theodor Marian Tal'ovskyi" (here and after the translation is ours) (Rymar, 2012).

Boitsun says that "in 1954, there were some explosions heard during several days when the Catholic Church was blasted. In 1959, a supermarket was opened there to celebrate the anniversary of the October Revolution. Many elements of the Church ornamentation were taken to Poland. Part of high reliefs of the sacred procession and the sculpture of Madonna were preserved in the Medium Church (the Church of the Nativity of Christ)" (Boitsun, 2003). That is why, we consider it of great importance to restore this architectural monument to preserve Ternopil's cultural heritage.

3.3 Methodology of the Design Engineering Stage

The creation of a 3D model of an object from its two-dimensional projections (photographs), that is, its 3D reconstruction, is carried out according to the following basic techniques: using design using 3D scanners, by obtaining a sequential series of images of an object from all sides, using a stereopair (Andrianova and Danilova, 2020).

It is a priori impossible to use the 3D scanning technique for the graphic reconstruction of the lost historical architectural objects. Therefore, we consider it inappropriate to consider this technique.

Graphic reconstruction by design involves the creation of a digital model using specialized software products. When creating a model, you can use ready-made drawings or develop a new one. Thus, it is possible to reproduce various objects that already exist in the real world, create those that have not yet been built, or carry out a graphic reconstruction of those that have been destroyed. This reconstruction method provides for modelling in various ways: based on primitives, sections, Boolean operations, arbitrary surfaces constructed using various mathematical models.

This method has a number of advantages, one of which is the construction accuracy. However, for the reconstruction of lost historical architectural objects, this method requires additional information, because, as a rule, in such cases, there are not enough drawings, plans of the area and the building. Therefore, it is advisable to combine it with the method of graphic reconstruction based on a set of images of an object from different sides.

The method of graphical reconstruction of an object from a set of images uses a sequential series of its images. In this case, the required percentage of overlap of two adjacent frames should be more than half, and the minimum 0 – the number of frames, overlap is equal to three.

The algorithm for implementing the work of this method consists of the following stages:

1) analysis of photographs of the object under study;

2) search for singular points and solution of a system of equations obtained on the basis of a set of data points;
3) search for "identical" points on different sets of adjacent images of an object;
4) calculating the coordinates of points from the "base" image of the object;
5) mapping of points in the coordinate system most convenient for object analysis and structure imposition.

The disadvantage of this method is the need for a large number of photographs for analysis in order to obtain high-quality results of graphic reconstruction.

In order to solve the problem of insufficient graphic information based on image analysis, we propose to use the method of graphic reconstruction using a stereopair. The method is based on obtaining and processing a set of pairs of images. In this case, the selection of points of correspondence, their comparison and geometric transformations are carried out. Obtaining a pair or series of images in which parallax is observed is the main task of this method. Here, to build a 3D model, you need to perform an algorithm of actions: determining the fundamental matrix, finding the corresponding points, building a point cloud, texturing. However, the model built using this method cannot be considered a full-fledged method of graphic reconstruction, since in this case only a surface view of the object is built.

Based on the analysis, we have proposed a comprehensive methodology for the graphic reconstruction of historical architectural objects for the implementation of the design stage. This technique consists in constructing a 3D model of an object, based on modern 3D design technologies, using methods for analysing archival descriptive information and data on a set of images and processing technology for a stereopair data array.

So, according to our proposed methodology for constructing a 3D model for the graphic reconstruction of a historical building, it is carried out on the basis of the cyclical execution of the following stages (Hevko et al., 2020a):

1. Search for information to create an accurate model from a set of images.
2. Creation of a model in the 3DS Max software environment.
3. Selection of the correct dimensions and construction of small parts diagrams based on the analysis of parallax image evaluation.

Thus, the programmed reconstruction process provided for the restoration of the building according to the data indicated in the sources (description, photographs, drawings), as well as on the basis of certain parameters according to the comparison of descriptions and data on the construction technologies of cathedrals of that time. The construction of a 3D model is based on a stereopair layout of the image of the destroyed Parochial Cathedral.

To restore the spatial configuration of objects, a parallax estimation of images was carried out. The principle of this assessment is that after processing a pair of stereo images, for each element of the left image, the corresponding element is found on the right image. The difference in the horizontal coordinates of the corresponding points (parallax) qualitatively reflects the distance to the image point (Riabokon, 2002).

Collection of data involves searching for cartographic materials as well as images and texts to facilitate accomplishment of the set task. Digital data are preferable followed by vector and raster images. While searching for information, we use a photograph of the Parochial Cathedral with sharp images of elements of the architectural object to create its precise model (figure 2).

In applying 3D modelling methods, special attention is paid to geometrical modelling considering the type of the modelled object (engineering, design, architectural, etc.) and the technology applied (Lytvyn, 2015).

Guided by detailed analysis of over 20 photographs of the Cathedral and its layout, we build a 3D model of the object. Thus, the above-described procedures result in a primary platform of the model.

The next actions are aimed at editing forms of the basis according to the photographs available. After completing detailed analysis of sizes and architectural features, we make amendments by means of relevant 3DS Max tools (Smith, 2006). After that, the building acquires a more realistic appearance. The complex character of building the model involves numerous fine details, their asymmetry and location in different planes.

Next, we perform detailed processing of walls and domes. To reduce labour-consuming procedures of model building, repeated details like windows can be copied and dragged to the required location. If you need to resize the element, its plane or angle, then it is possible to do it using the functions of the software environment.

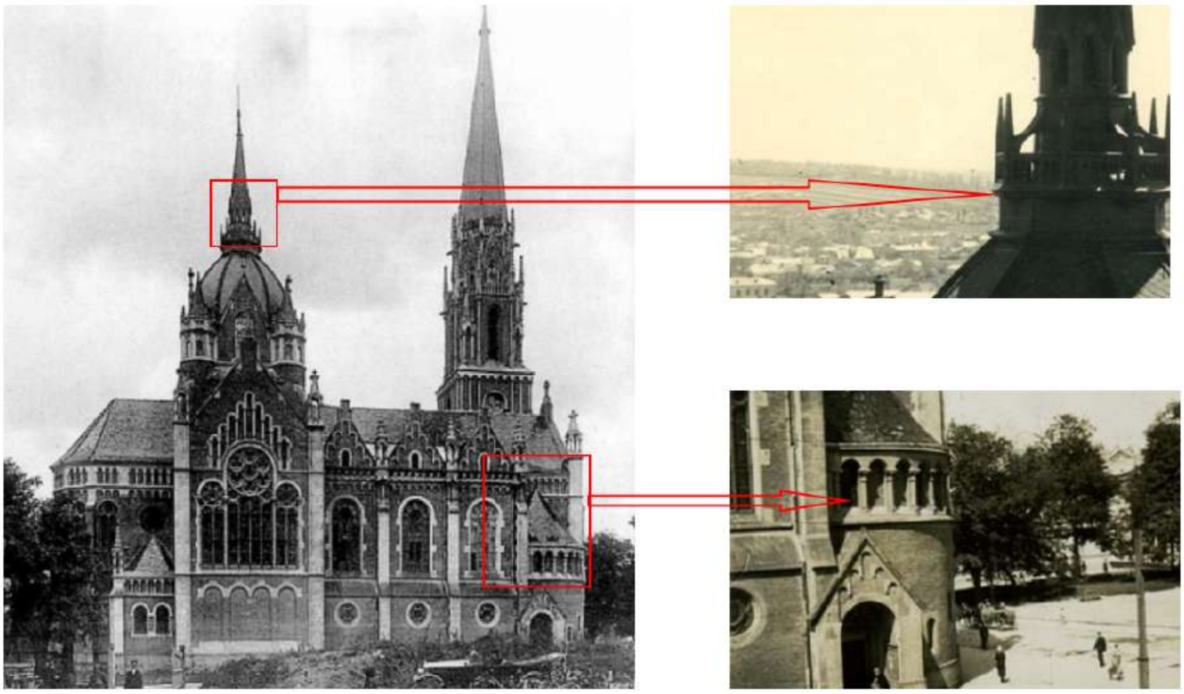

Figure 2: Analysis of the spatial configuration and details of the cathedral of the Parochial Cathedral of St. Mary.

3.4 Implementation of the Design Stage of the Proposed Methodology

For the sake of convenience, we apply appropriate functions to revolving and moving the model. Thus, after completing a series of actions and operations, we obtain a 3D model of the Parochial Cathedral. To make the image of the model more realistic, we perform its rendering.

Rendering is responsible for applying various special effects, detailing and fine-tuning components. A texture map is also being prepared. First of all, materials are assigned, after which parameters are set, such as roughness, reflection, transparency, etc. Also, light sources and cameras are set. So, at this stage, the 3D visualization settings are clarified and adjusted.

The primary and the resulting 3D models of the cathedral after the stage of analyzing the dimensions and features of the architecture are shown in figure 3.

Before making a printed miniature of the 3D model, we should analyse and adjust it properly. As the target result of modelling is a printed miniature, the built model should be exported into the STL-format. It should be noted that due to the intensive development of 3D printing, most specialized programs support this feature. This type supports 3D objects by preserving them as a bulk of triangular data describing a surface.

3.5 The Sequence and Content of the 3D Printing Stage

The first stage of preparing the model for printing provides for analysis of 3D model geometry, which involves its testing for available open spaces in the polygonal net, some displacements of polygons and defects in geometry.

The next stage includes analysis of all parameters, sizes and their test for conformity with printing materials. As the built 3D model has sizes of a real-life building, it requires scaling to create its printable miniature (figure 4).

Nowadays, there is a great variety of software for 3D printing, among which one should mention Cura, CraftWare, Slic3r, 3DTin and Repetier-Host. These software products are quite widespread due to their advanced features and relative complexity.

Yet, being guided by convenience and a relatively user-friendly interface, we apply Cura in which except for standard editing tools, printing quality adjustment and material parameters, there are functions of calculating weight of the end item, its print time, etc (Mitin, 2018).

Basic settings of technological parameters include printing quality, filling, printing speed and temperature, parameters of printing support and plastic threads. While setting the parameters of printing quality, the most essential one is the layer height

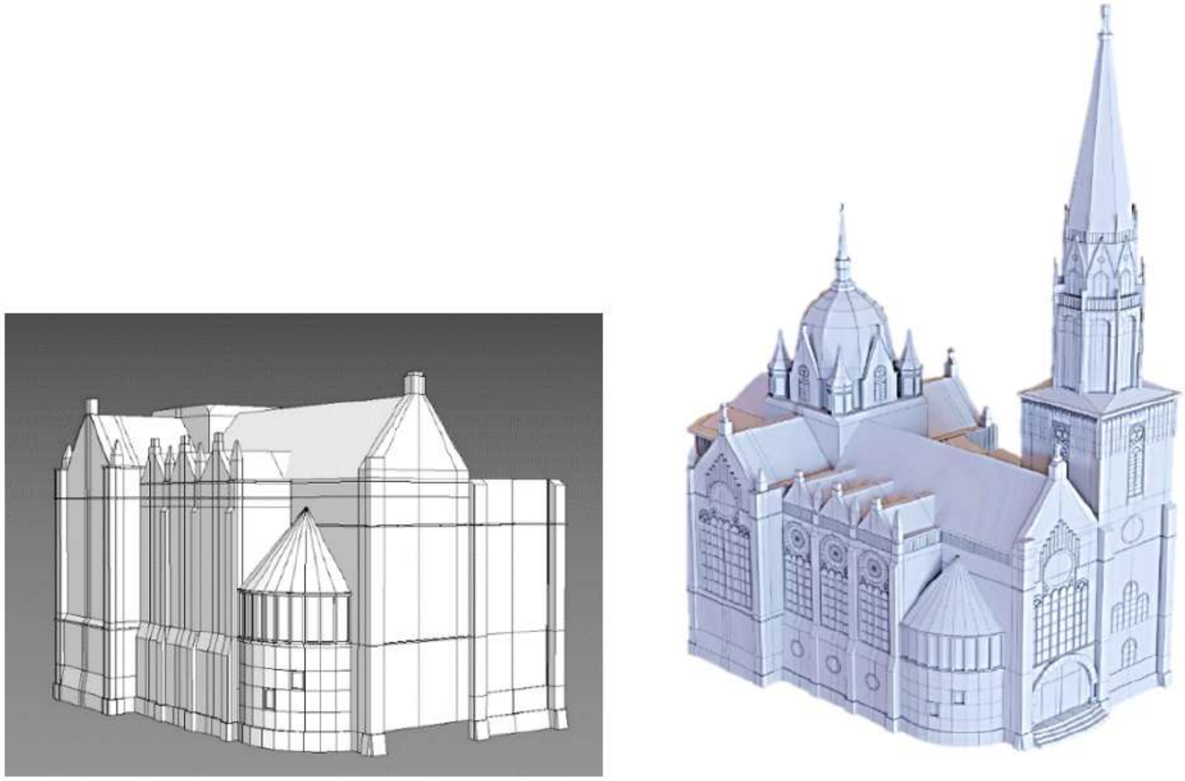

Figure 3: The primary and the resulting 3D models of the Parochial Cathedral.

(mm) determined by the nozzle diameter and it should not exceed its half.

Shell thickness (mm) determines thickness of printing walls of thin-wall objects or objects with the reduced in-fill ratio. Shell thickness is determined by corresponding geometrical parameters of an object. For small models, the thickness of 10–30 mm is optimal.

Economic factors of plastic consumption are determined by fill density (%). In most cases, the in-fill ratio makes 10%, yet, for inflexible models and considering structural features of a model, the in-fill ratio can reach 100%. However, printing time increases greatly.

Settings of print speed and temperatures enhance qualitative and technological parameters of printing. The most significant parameter is print speed that determines nozzle movements. As our model has many fine details, the set speed is 30 mm/sec to make printing accurate. It is caused by the fact that high print speed affects its quality because of vibration efforts on the supporting frame of a printer and accelerated wear of drive elements.

The technology also provides for printing auxiliary model elements (not specified in geometry) considering lack of possibility to form plastic mass in the air. This support is possible for both individual model elements (support type) and its platform (platform adhesion type). In this case, we select the function Brim to provide high-quality print of model elements, which are hanging (the roof, domes). The programme creates additional supports for these elements.

After setting the required parameters to make a miniature, the file is sent to the printer with automatically formed G-code and approximate print time and the amount of the required material are determined.

Figure 5 presents a printed model of the Parochial Cathedral based on the suggested 3D modelling technology, the advantages of which are availability and low costs of produced models.

The methodology for creating the 3D model and printing the layout of the Parish Cathedral has been carried out by specialists of the Innovative Center for 3D Technologies of Design and Production, which operates on the basis of the Chair of Computer Technologies of the Ternopil Volodymyr Hnatyuk National Pedagogical University.

Some specific features of the developed model indicate possible further application of the methods to reconstruction activity in order to preserve the city and the state cultural heritage.

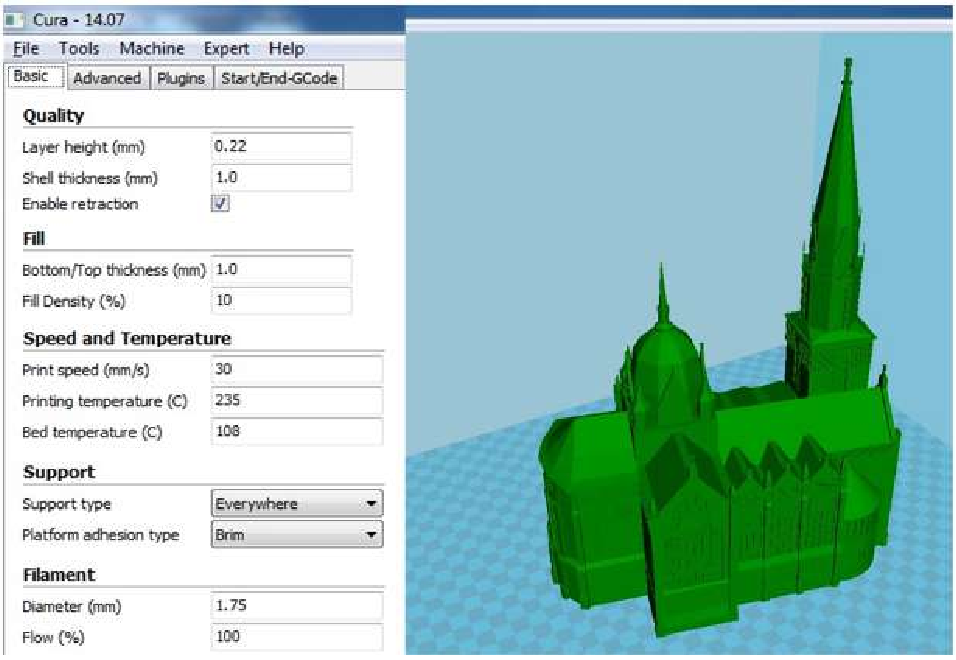

Figure 4: Adjusting the model sizes to printing.

4 JUSTIFICATION OF THE EFFECTIVENESS OF THE PROPOSED METHOD

Our research on improving the methodology for teaching of constructing 3D models of historic architectural objects was based on the proposed algorithm for performing architectural and spatial shaping in the process of reproducing an historic object.

In the process of teaching future IT specialists to 3D technologies, we focused on the use of a comprehensive methodology for studying the graphic reconstruction of historical architectural objects. This methodology consists in the formation of skills in constructing a 3D model of an object based on design technologies according to image analysis using parallax evaluation of the data array of stereopairs of images of the objects under study.

The proposed technique forms in students' certain preliminary skills for the implementation of graphic reconstruction, which are important for their future professional activities. To substantiate the effectiveness of the proposed technique, an experimental study was carried out. In the course of the study, methodological support was developed for conducting a cycle of laboratory studies.

Carrying out such a study helped to find out the effectiveness of the proposed methodology, to create conditions for the introduction of positive achievements into the educational process.

A pedagogical experiment to test the effectiveness of the methodology for the formation of graphical reconstruction skills in future IT specialists covered 27 students of the specialty "Professional Education (Computer Technologies)". The distribution of students for the experiment was carried out as follows: the EG (14 students) – the experimental group, and the CG (13 students) – the control group. The research consisted in the introduction of the proposed methodology into the educational process of the EG, while the CG studied according to the traditional method.

All participants in the experiment were familiar with the purpose of the experiment and provided personal consent to participate. To test the effectiveness of the methodology, diagnostic tools were developed in the form of indicators, which were used to track a positive result in the formation of the skills of future IT specialists to carry out graphical reconstruction.

These indicators were: 1) knowledge about the technique of graphic reconstruction and the necessary tools; 2) knowledge of methods of geometric spatial design; 3) the ability to use software tools for building 3D models; 4) the ability to use image analysis technologies based on stereo pairs and parallax assessment; 5) knowledge of 3D printing technology.

These indicators made it possible to characterize four levels of skills of future IT specialists to carry out graphical reconstruction:

1) low (characterized by low motivation to use

Figure 5: The printed miniature of the Parochial Cathedral of St. Mary of the Perpetual Assistance.

graphic reconstruction technologies in professional activity and creative self-realization; lack of geometric design skills; elementary theoretical and technological training in the use of specialized software for solving problems of graphic reconstruction and 3D printing; fragmented ability to analyse graphic information);

2) medium (characterized by a limited interest in graphic reconstruction technologies and in the use of computer visualization tools, partial skills to analyse graphic information and a situational desire to introduce software tools for the design of spatial objects in professional activities and the need for additional motivation, mediocre theoretical and technological training in the use of 3D print);

3) sufficient (characterized by significant motivation for the use of graphic reconstruction technologies, spatial modelling tools in professional activities, thorough training in the use of specialized software for solving typical tasks of graphic reconstruction and 3D printing, understanding of the process of analysing graphic information using arrays of digital data, readiness to reproduce typical models of graphic reconstruction);

4) high (characterized by a conscious and reasoned motivation for the use of graphic reconstruction technologies, means of spatial modelling in professional activities and for creative self-realization, thorough training in the use of specialized software for solving creative problems of graphic reconstruction and 3D printing, the ability to evaluate graphic information and analyse arrays digital data corresponding to a graphical representation of a spatial object, formed by a sense of willingness to create their own models of graphical reconstruction).

Methods for determining achievements for the selected indicators were as follows.

1. Knowledge about the technique of graphic reconstruction and the necessary tools were tested with an appropriate set of test tasks.
2. Knowledge of methods of geometric spatial design was verified by tests.
3. The ability to use software tools for building 3D models was tested by executing the project.
4. Ability to use image analysis technologies based on stereo pairs and parallax assessments were tested by an individual task.
5. Knowledge of 3D printing technology was tested with an individual assignment.

During the experimental study, there were significant changes in the relationships between the knowledge levels of students in the control and experimental groups, which are reflected in table 2.

Analysis of the results of the experimental study showed that the quality of knowledge in the experimental group increased by 23.1%, and in the control group only by 14.3%, the average score increased accordingly: $\Delta\mu$ (EG) = 6.9; $\Delta\mu$ (CG) = 1.4. The dynamics of changes in the quality of knowledge of students from the EG and CG is presented in figure 6.

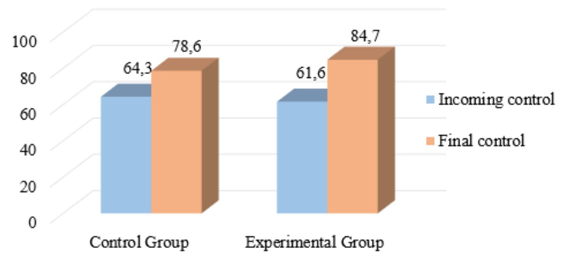

Figure 6: Dynamics of the quality of knowledge.

Consequently, conducting an experimental study using the proposed methodology proved its effectiveness in the educational process of future IT specialists. Thanks to the atypical approach to learning, a relaxed atmosphere is created, which contributes to a better assimilation of the material.

5 CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

Graphic reconstruction of historical architectural objects is possible due to new technologies of 3D graphics, modelling and design in specialized computer environments. The developed method 3D technologies of graphic reconstruction are exemplified by the modelling of the Parochial Cathedral of St. Mary of the Perpetual Assistance of the 1950s.

The proposed method of training of graphic 3D reconstruction is based on the principles: systematicy and consistency, accessibility, clarity, connection between theory and practice, combination of individual and collective. The stages of the proposed methodology (analysis, construction, design, model printing) are based on a general methodology, taking into account individual specifics, depending on the tasks to be solved, the selected software, the required degree of detail and realism.

Determination of the spatial configuration of objects provides for the restoration of the building according to the data indicated in the archival sources, as well as on the basis of the determined parameters according to the comparison of descriptions and data on the construction technologies of cathedrals of that epoch.

The complex method for the graphic reconstruction of historical architectural objects is proposed. This method consists in constructing a 3D model of an object, based on a combination of design techniques using modern 3D technologies, based on methods for analysing archival descriptive information and data from a set of images using a parallax evaluation of a stereopair data array of images of a destroyed Cathedral.

3ds Max is selected to build a 3D model of the object to enhance high accuracy, speed and granularity of fixing complex sets providing efficient tools of working with bulk data that incorporate new achievements of informational technologies.

Detailed analysis of images and determined sizes provides the basis for the 3ds Max model, which is then edited by relevant tools to make it more realistic. The complex character of building the model implies its numerous fine details, their asymmetry and location in different planes.

Creating a printed model of a 3D model requires its analysis and adaptation to 3D printing based on testing the model for the presence of open spaces in the polygonal mesh, defects in the geometry and checking for compliance with the print materials. To build a printed model of the Cathedral, guided by criteria of convenience and the user-friendly interface, the Cura software environment is applied.

The presented teaching methodology provides for the formation of a system of theoretical and practical knowledge of students in the process of model buildings design and structures using modern digital technologies of graphic 3D reconstruction.

To substantiate the effectiveness of the proposed

Table 2: Dynamics of the level of knowledge of students.

Group	Experiment stage	Total number of students	Grade Point Average, μ	Knowledge level							
				high		sufficient		medium		low	
				number of students	%	number of students	%	number of students	%	number of students	%
CG	I	14	78.7	4	28.6	5	35.7	4	28.6	1	7.1
	II		80.1	5	35.7	6	42.9	3	21.4	1	7.1
EG	I	13	75.3	3	23.1	5	38.5	3	23.1	2	15.3
	II		82.2	5	38.5	6	46.2	2	15.3	0	0

technique, an experimental study was carried out, during which the developed methodological support was tested. An analysis of the results of the experimental study showed that the implementation of the proposed methodology contributes to the high-quality training of future IT specialists. Carrying out such research helped to create conditions for introducing positive achievements into the educational process.

Prospects for further research are defined in two directions:

1) methodical: development of the training course "Graphic reconstruction of architectural objects" and its introduction into the educational process of the specialty "Professional education (Digital technologies)";

2) technological: reconstruction of the Cathedral interior that would enable creation of an object of the virtual historical museum of the architectural monument. Yet, this problem requires auxiliary data on the Parochial Cathedral of St. Mary of the Perpetual Assistance and remains unsolved to date.

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Selection Cloud-oriented Learning Technologies for the Formation of Professional Competencies of Bachelors Majoring in Statistics and General Methodology of Their Use

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Keywords: Criterion, Selection Criteria, Cloud-based Learning Technologies, Cloud Services, Bachelors Majoring in Statistics, the Methodology of Use.

Abstract: This article scientifically substantiates the criteria for the selection of cloud-oriented learning technologies for the formation of professional competencies of bachelors majoring in statistics, as well as presents the results of expert evaluation of existing cloud-oriented learning technologies by defined criteria. The criteria for the selection of cloud-oriented learning technologies for the formation of professional competencies of bachelors majoring in statistics were determined: information-didactic, functional, and technological. To implement the selection of cloud-oriented learning technologies for the formation of professional competencies of bachelors majoring in statistics, and effective application in the process of formation of relevant competencies, the method of expert evaluation was applied. The expert evaluation was carried out in two stages: the first one selected cloud-oriented learning technologies to determine the most appropriate by author's criteria and indicators, and the second identified those cloud-oriented learning technologies that should be used in the educational process as a means to develop professional skills Bachelor of Statistics. According to the research, the most appropriate, convenient, and effective cloud-oriented learning technologies for the formation of professional competencies of future bachelors of statistics by the manifestation of all criteria are cloud-oriented learning technologies CoCalc and Wolfram Alpha. The general structure of the methodology of using cloud learning technologies for the formation of professional competencies of future bachelors of statistics is described.

1 INTRODUCTION

The European integration processes, change, and development of the educational system of Ukraine creates new requirements for the training of specialists in almost all spheres of human life. The formation of general competencies is the basis of general education, and the formation of professional competencies of future specialists is carried out in the process of education in higher education institutions (HEI). Traditional learning is out of date and needs updating, replenished with new technologies, forms, means, and is confirmed in the text of the National Doctrine of Educational Development that "continuous improvement of the quality of education, updating its content and forms of organization of educational process; development of the system of continuous education and training throughout life; introduction of educational innovations, information technologies" (President of Ukraine, 2002).

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An important achievement in the field of education has been the creation of open education platforms based on the implementation of the principle of the functioning of cloud technologies; comprehensive updating of training technologies, methodological support, and content of distance and e-learning based on the introduction of information and communication technologies (ICT); introduction of new forms and methods of teaching based on cloud-oriented technologies, Web 2.0 technologies, services of electronic social networks (Kremen, 2016).

Formation of professional competencies of specialists, including the future bachelor of statistics, is carried out during the training at HEI, and the use of the latest information and communication technologies is an important key element in this process. That is why one of the leading areas of qualitative training of specialists in the requirements of today is the application of cloud technologies, and in the educational process – cloud-oriented learning technologies (COLT).

Research on evaluating the effectiveness of ICT learning has largely highlighted the problem of evaluating learning outcomes.

The analysis of existing ICTs, criteria, and indicators of their selection were analyzed and highlighted in (Bykov et al., 2014; Golovnia, 2015; Demyanenko et al., 2013; Kolos, 2013)

In particular, Bykov et al. (Bykov et al., 2014) considered open web-oriented systems for monitoring the implementation of scientific and pedagogical research results. Golovnia (Golovnia, 2015) in her works investigated the virtualization software in the training of UNIX-like operating systems and identified the criteria and indicators of their selection. Demyanenko et al. (Demyanenko et al., 2013) give methodological recommendations on the selection and use of electronic tools and resources for educational purposes. Kolos (Kolos, 2013) has developed criteria for selecting components of a computer-oriented educational environment for a postgraduate teacher education institution. Spirin (Spirin, 2011) offers criteria for external evaluation of the quality of information and communication training technologies.

The use of cloud technologies in education is shown in (Shyshkina and Marienko, 2020; Valko et al., 2020; Lovianova et al., 2019; Lytvynova, 2018; Merzlykin et al., 2017; Symonenko et al., 2020; Popel et al., 2017; Velychko et al., 2020; Vlasenko et al., 2020; Volikova et al., 2019).

In particular, the problem of developing a methodological system for the use of a cloud-oriented environment in the training of databases of future computer science teachers was investigated by Korotun (Korotun, 2018). The question of designing a cloud-oriented educational environment of a comprehensive educational institution was also investigated by Lytvynova (Lytvynova, 2016). Several teams of authors have considered cloud technologies in learning at different intervals (Shyshkina and Popel, 2013; Valko et al., 2020; Lytvynova, 2018; Glazunova et al., 2017; Seidametova et al., 2012; Markova et al., 2015; Striuk and Rassovytska, 2015). At the same time, the question of research into the use of cloud technologies in training future bachelor of statistics and the development of appropriate criteria and indicators of selection have not been sufficiently studied.

The purpose of the article is to define criteria and establish appropriate indicators for the selection of cloud-oriented learning technologies to shape the professional competencies of bachelors majoring in statistics and to develop a general methodology for the use of selected cloud-based learning technologies for the specified type of activity.

2 METHODS

An expert evaluation method was used to implement the selection of the COLT for the formation of the professional competencies of future bachelors of statistics and for effective application in the process of forming the corresponding competencies (Zastelo, 2015; Gavryliuk et al., 2020). According to the purpose and objectives of the method, the corresponding COLT is numbered in ascending or descending order based on a separate trait, by which further ranking is made. It should be noted that the peer review was carried out in two stages.

In the first stage, experts were asked to evaluate 8 COLT that could be used in the process of forming the professional competencies of future bachelors of statistics.

In the second phase of the study, another group of specialists was recruited to evaluate the most significant COLT according to certain criteria.

3 RESULTS

3.1 Selection of Cloud-based Learning Technologies for the Formation of Professional Competencies of Future Bachelors of Statistics

Research on the implementation of cloud-oriented learning technologies to shape the professional competencies of future professionals is being actively pursued by various researchers. As this research is aimed at COLT to shape the professional competencies of future Bachelor of Statistics, it is important to identify, by a certain set of criteria, the most effective, convenient, and relevant cloud-oriented learning technologies to be used in the educational process of HEI.

To begin with, we will define the term “criteria”, since this definition is presented differently by different researchers.

In encyclopedic reference publications, the concept of “criterion” is defined as “a trait, a basis for evaluation, taken as a basis for classification” (Busel, 2005).

In (Honcharenko, 2000) the criterion is called “the criterion for evaluating something, a means of verifying the truth or falsehood of a statement”.

Bagrii (Bagrii, 2012) argues that the criterion is “a standard against which to evaluate, compare a real pedagogical phenomenon, process, or quality by reference”.

Torchevsky (Torchevsky, 2012) notes that “in the most general form, the criterion is an important and defining feature that characterizes the various qualitative aspects of a particular phenomenon under study, helps to clarify its essence, helps to specify the main manifestations. In this regard, the indicator is a quantitative characteristic of this phenomenon under study, which makes it possible to conclude on the state of statics and dynamics”.

In Dychkivska (Dychkivska, 2004) term “criterion” is defined as “an indicator that characterizes the property (quality) of an object, the evaluation of which is possible using one of the measurement methods or the expert method”.

Under the selection criteria of COLT for the formation of professional competencies of future bachelors of statistics, we will understand such features, qualities, and properties of cloud-oriented technologies that are required for their effective use in the educational process to form the professional competencies of future bachelors of statistics.

We apply the method of expert evaluation (Zastelo, 2015; Gavryliuk et al., 2020). In the first stage, experts were asked to evaluate 8 COLT that could be used in the process of forming the professional competencies of future bachelors of statistics.

20 experts of different profiles were invited to the expert evaluation procedure, among them officials of the State Statistical Service of Ukraine and the State Treasury in Zhytomyr, employees of banking institutions, employees of commercial financial institutions.

A point scoring system was used in the study (Spirin and Vakaliuk, 2017). According to the aforementioned evaluation system, for the number of N COLT, the maximum possible estimate of N is given to the most significant in the use of COLT and 1 to the least significant. The results of the assessment are presented in the form of a table, where the columns indicate the hotline number and the fields the expert number. The COLT name card is presented in alphabetical order (A to Z), to prevent psychological clues that could affect the outcome of the assessment.

To determine whether there is an objective agreement between experts, calculated Kendall’s Concordance Coefficient W by the appropriate formula specified in (Zastelo, 2015; Gavryliuk et al., 2020).

The results of the peer review are presented in table 1.

The result was selected COLT 4: CoCalc, Scilab, WebMathematica, Wolfram Alpha.

After calculating based on the experimental data presented (table 1), obtained a coefficient of concordance $W = 0.71$. Since the value obtained is non-zero, there is an objective agreement between experts.

In the second phase of the study, another group of specialists was recruited to evaluate the most significant COLT according to certain criteria. It is worth noting that the second stage involved 15 specialists of different profiles, namely: teachers, heads of departments and deans of faculties of higher education institutions of Ukraine, having experience and related to the professional training of future bachelors of statistics, employers (Main Department of Statistics in Zhytomyr region, Department of the State Treasury Service of Ukraine in Zhytomyr, Main Department of State Tax Service in Zhytomyr region, heads of state and commercial banks, managers financial companies), which worked directly with the selected COLT and could objectively evaluate them according to the degree of manifestation of each criterion.

The manifestation of each of the presented criteria was evaluated for each of this COLT. To this end, experts have been asked to evaluate its performance using the scale shown in table 2.

The indicator will be considered positive if the arithmetic mean of these points is at least 1.5. If more than half (50%) of the indicators of the relevant criterion are negative, then the criterion is defined as insufficiently developed. In the case of:

- when 50–55% of the indicators of the criterion are positive, the criterion is characterized as critically manifested;
- if 56–75% of the indicators of the criterion are positive, then the criterion is characterized as sufficiently manifested;
- if 76–100% of the criterion indicators are positive,

Table 1: Ranking cloud-oriented learning technologies for the formation of the professional competencies of future bachelor of statistics.

Expert number	COLT							
	CoCalc	Excel Online	GeoGebra	Google Sheets	Maple Cloud	Scilab	Web Mathematica	Wolfram Alpha
1	6	4	2	1	3	5	7	8
2	6	5	1	2	3	4	8	7
3	8	1	2	3	4	5	7	6
4	5	3	2	1	4	8	7	6
5	5	2	1	4	3	6	7	8
6	6	1	5	2	3	4	8	7
7	8	2	3	1	5	4	7	6
8	5	3	1	2	4	6	7	8
9	6	1	4	3	2	5	8	7
10	7	1	2	3	4	8	5	6
11	7	3	2	4	1	6	5	8
12	5	2	3	6	1	4	8	7
13	8	1	2	3	4	5	6	7
14	6	4	1	3	2	5	8	7
15	7	4	1	3	2	5	6	8
16	5	3	2	4	1	6	8	7
17	8	2	1	3	5	4	7	6
18	7	1	2	3	4	8	5	6
19	4	3	2	1	8	7	5	6
20	7	4	1	2	3	6	5	8
S	126	50	40	54	66	111	134	139
d	36	-40	-50	-36	-24	21	44	49

Table 2: Scale bar for evaluation of the relevant criteria.

Scores	Evaluation of the indicator
0	the indicator is missing
1	the indicator is partially available (not available more than available)
2	the indicator is more available than not available
3	the indicator is completely available

then the criterion is characterized as highly manifested (Spirin and Vakaliuk, 2017).

An analysis of existing cloud-oriented learning technologies to shape the professional competencies of future bachelors of statistics has made it possible to identify the criteria and relevant indicators of these cloud-oriented learning technologies:

- information-didactic: information support; coverage of various sections of mathematics and statistics; graphical presentation of results; teamwork on the project; ability to apply programming knowledge;
- functional: user-friendly interface; free of charge; accessibility; multilingualism;
- technological: cross-platform; integration with other cloud services; adaptability.

The results of the peer review of each of the selected criteria and relevant indicators will be discussed in more detail.

The information-didactic criterion characterizes the information and didactic component of cloud-oriented learning technology and is based on the laws of assimilation of knowledge, skills, and competences, namely:

- the indicator “information support” characterizes the presence of a description of the use of the tool, examples, or the presence of a section of assistance;
- the indicator “coverage of various sections of mathematics and statistics” characterizes the possibility of using COLT in the process of studying certain sections of mathematics and statistics;
- the indicator “graphical presentation of results”

characterizes the ability to interpret the results in the form of graphs, histograms, or a three-dimensional model;

- the indicator “teamwork on the project” characterizes the ability to work with multiple users at the same time;
- the indicator “ability to apply programming knowledge” characterizes the ability to take individual actions to perform calculations using different programming languages.

Basic data on indicators of information-didactic criteria for each of the selected COLT contains table 3.

The functional criterion characterizes the functional component of cloud-oriented learning technologies and assumes the following indicators:

- the indicator “user-friendly interface” describes the convenience and comprehensibility of the interface and the computational component of the software system;
- the indicator “accessibility” characterizes the provision of cloud-oriented learning technology to different categories of users;
- the indicator “free of charge” characterizes the possibility of free or full use of cloud-oriented learning technologies;
- the indicator “multilingualism” characterizes the support of multiple languages (localization) of the interface.

The basic data on the indicators of the functional criterion for each of the selected COLT contains in table 4.

The technological criterion is characterized as follows:

- “cross-platform” indicates the possibility of using cloud-oriented learning technologies in different operating systems;
- the indicator “integration with other cloud services” implies the possibility of supporting the work with calculations in different cloud services, and the possibility of further integration with other services;
- “adaptability” indicates the possibility of full use of cloud-oriented learning technologies on different devices (desktop PC, laptop, netbook, tablet, smartphone, etc.).

The basic data on the indicators of the technological criterion for each of the selected COLT contains table 5.

Let’s summarize the results of the study in table 6.

3.2 The General Structure of the Methodology of using Cloud-based Learning Technologies for the Formation of Professional Competencies of Future Bachelors of Statistics

The formation of professional competencies is a long process that requires, in addition to appropriate teacher training, the use of appropriate methods of its implementation.

The methodology of using cloud-based learning technologies for the formation of professional competencies of future bachelors of statistics includes the purpose of the application, the content of an application, interrelated forms of training, methods, and tools for achieving a predictable result.

The expected result of the methodology is the formed professional competencies of future bachelors of statistics in the specialty 112 “Statistics”.

The purpose of using cloud-based learning technologies is to form in future bachelors’ statistics of professional competencies.

The content of the methodology involves improving the learning process of disciplines of general training of the variable part of the free choice of students using cloud-based learning technologies (on the example of the content of the variable discipline of “Computer Statistics”).

Note the features of teaching the discipline “Computer Statistics” for the training of future bachelors of statistics using cloud-based learning technologies.

To improve and enhance the discipline “Computer Statistics” carried out:

- selection of cloud-based learning technologies that are appropriate and reasonable to use in the learning process of future bachelors of statistics, to form their professional competencies;
- improving the content of the variable discipline “Computer Statistics” for the use of cloud-based learning technologies during the acquaintance and mastery of relevant topics of the course;
- development of methodical recommendations on the use of cloud-based learning technologies in the educational process of the discipline “Computer Statistics”.

The purpose of the discipline is based on the mastery of practical skills of future professional activity in conditions that are as close as possible to the real ones; to form professional competencies in applicants related to a thorough knowledge of the chosen field

Table 3: The information-didactic criterion for selection of cloud-oriented learning technologies and the value of its indicators.

COLT	The indicators						
	Information support	**Coverage of various sections of mathematics and statistics**	**Graphical presentation of results**	**Teamwork on the project**	**Ability to apply programming knowledge**	**The manifestation of the criterion**	**The level of manifestation**
CoCalc	1.93	2.67	2.07	1.80	2.00	100%	highly
Scilab	2.13	2.20	0.80	0.80	2.33	60%	sufficiently
WebMathematica	1.47	2.00	1.33	1.53	2.13	80%	highly
Wolfram Alpha	2.33	2.27	2.33	1.53	2.33	100%	highly

Table 4: The functional criterion for the selection of cloud-oriented learning technologies and the value of its indicators.

COLT	The indicators					
	User-friendly interface	**Free of charge**	**Accessibility**	**Multilingualism**	**The manifestation of the criterion**	**The level of manifestation**
CoCalc	1.80	2.00	2.20	1.80	100%	highly
Scilab	2.00	1.87	2.13	1.53	100%	highly
WebMathematica	1.73	1.87	1.73	1.93	100%	highly
Wolfram Alpha	2.13	2.53	2.20	1.60	100%	highly

of statistics, the ability to perform a qualitative analysis of data or calculations, calculations of relevant processes, the ability to work with statistical information, the use of appropriate software and cloud services, able to work both independently and in a team.

The study of the discipline "Computer Statistics" assumes that applicants for the specialty 112 "Statistics" *must know* the basic concepts of mathematical statistics; stages of statistical research; specialized programming languages, in particular, the statistical programming language R; software for working with statistical data; specialized cloud services for organizing work with statistical information; features of the organization of joint work using cloud services; *be able* to perform statistical calculations; perform statistical calculations using specialized software; perform statistical calculations using appropriate cloud services; transmit and receive statistics; analyze the obtained data; build and edit schedules; visualize the received data with the help of specialized cloud services; organize joint activities with other specialists of the relevant activity or clients for whom the statistical survey is carried out.

Consider the modules that form the content of the advanced program of the discipline "Computer Statistics":

Module 1. Working with data. Basics of work in R.

Content module 1. Basic concepts, data types, and elementary functions. Arithmetic and logical operations. Basic mathematical functions. Vectors. Matrices. Arrays and data frames.

Content module 2. Export and import of data in R. Export of data, import of data in internal format. Export and import data tables.

Content module 3. Programming in R. Creating your functions. The technique of vectorization of the function. Conditional use (if) and multi-conditional (switch) operations. While and repeat loops. Cycle for.

Module 2. Basic concepts of statistical distribution.

Content module 4. Basic probability distributions. General concepts of distribution. The most commonly used distributions.

Content module 5. Graphic representation of statistical distributions. Points on the plane. Charts. Construction of histograms. Elements of three-dimensional graphics.

Module 3. Statistical evaluation and statistical testing

Table 5: The technological criterion for the selection of cloud-oriented learning technologies and the value of its indicators.

COLT	The indicators				
	Cross-platform	**Integration with other cloud services**	**Adaptability**	**The manifestation of the criterion**	**The level of manifestation**
CoCalc	1.53	1.53	1.93	100%	highly
Scilab	1.53	1.53	1.53	100%	highly
WebMathematica	1.73	1.73	1.93	100%	highly
Wolfram Alpha	2.60	2.33	2.93	100%	highly

Table 6: Generalized results of the selection of cloud-oriented learning technologies by the manifestation of all criteria.

COLT	Criterion		
	Information-didactic	**Functional**	**Technological**
CoCalc	100%	100%	100%
Scilab	60%	100%	100%
WebMathematica	80%	100%	100%
Wolfram Alpha	100%	100%	100%

of hypotheses.

Content module 6. Evaluation of unknown parameters. The method of moments. Quantile method. The method of the highest probability. Confidence intervals.

Content module 7. Test of statistical hypotheses. General concepts of the theory of hypothesis testing. Algorithm for testing statistical hypotheses. Pearson's criterion. Kolmogorov's criterion.

The proposed technique involves the use of the following teaching methods of selected cloud-based learning technologies (CoCalc and Wolfram Alpha, as described above and in (Gavryliuk et al., 2020)):

- *Explanatory and illustrative*. Statistics as a science is quite complex and contains many sections that contain a significant amount of theoretical material, theorems and proofs, formulas, and graphical constructions of relevant processes. The explanatory-illustrative method as the most appropriate to use because students receive accurate theoretical material from the teacher, or independently from the textbook or textbook with subsequent discussion in class or online, and receive a visual presentation of the material using selected cloud-based learning technologies, demonstration of practical application cloud-based learning technologies CoCalc and Wolfram Alpha (figure 1). Explaining the theoretical aspects of statistics is a basic factor influencing students' further understanding of the following related topics in the course, the use of cloud-based learning technologies to effectively perform professional tasks and the formation of professional competencies of future bachelors of statistics.
- *Reproductive*. Given the accuracy and complexity of the theoretical material, the course of the discipline "Computer Statistics" provides for laboratory and practical work, which is planned to practice tasks of varying complexity according to the specified algorithm according to the relevant educational topic, as well as a demonstration of their cloud-based learning technologies. CoCalc and Wolfram Alpha followed by a repetition of the action scenario by the students. It is planned to present ready-made solved exercises and perform exercises in a similar way (two or three exercises or tasks). Also, it can be pre-prepared by the teacher sets of statistics provided to students as a separate file in the cloud storage or ready-presented statistical sets presented on the MEI page (Mathematics Education Innovation, http://mei.org.uk/data-sets), or on Google Public Data, Google Dataset Search services.
- The method of *problem statement* can be effectively used during practical or independent work, during which students do not receive samples of problem-solving or ready-made algorithms for working with cloud-based learning technologies. The teacher describes the problems or asks the formed problem question (one or more), describes the ways to solve the problem, acts as a mentor who guides the work of students. Working in such circumstances promotes the development of students' critical thinking, solving atypical situations, and forms professional competencies, in particular, to develop research and analyze the data obtained; ability to present the results to the

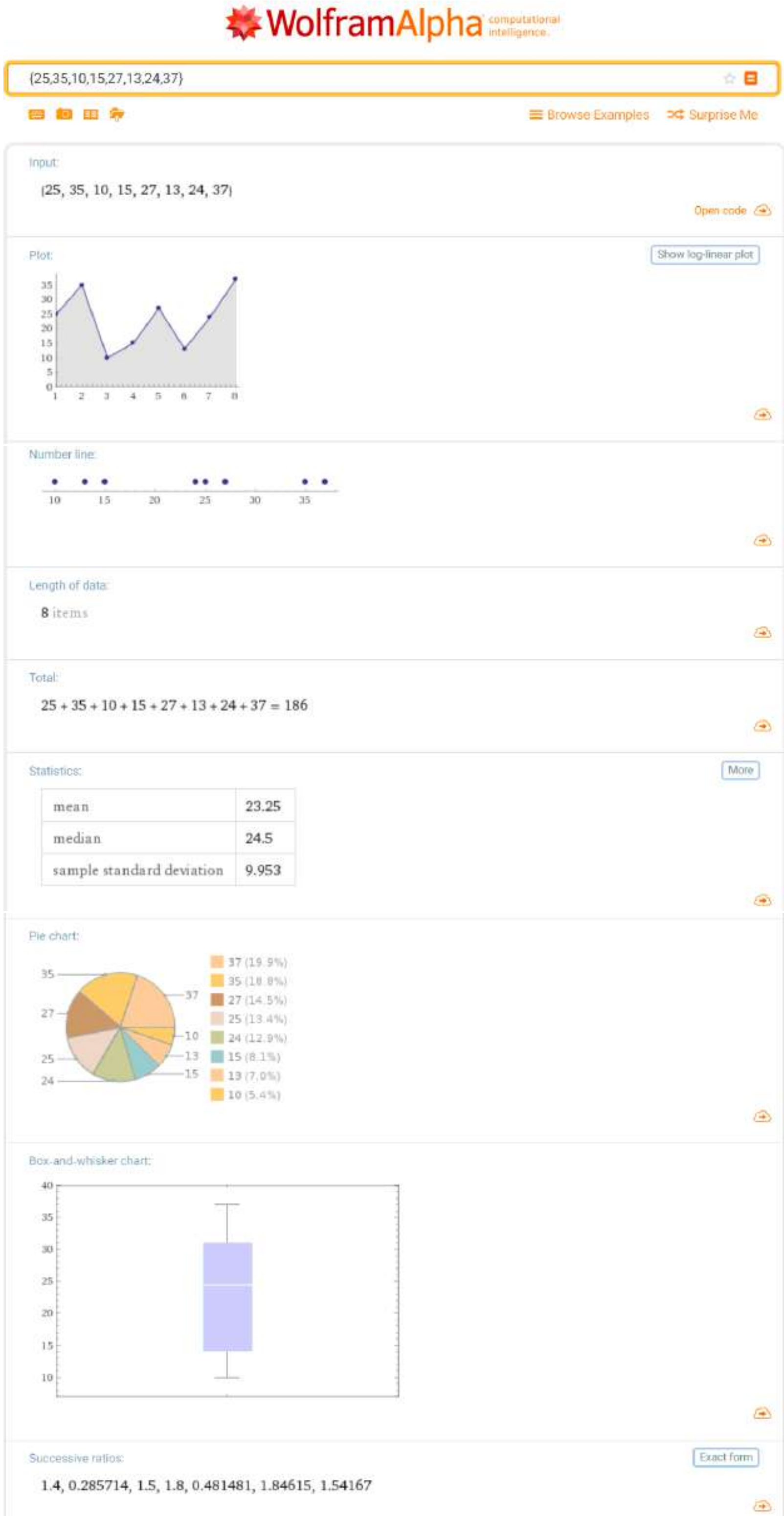

Figure 1: The result of sampling calculations in the Wolfram Alpha service.

target audience; ability to work in a team.

- *Partial search.* The study material is presented by the teacher in part (a certain part of the topic), and the rest of the students work independently. However, the teacher directs the work of applicants with questions or pre-selected tasks to prevent errors in their activities or found the wrong solution.
- *Research.* The method is quite difficult to use because it requires additional training from the teacher and is quite time-consuming. Provides independence of students in the study of a particular topic or theoretical aspect, its practical implementation in cloud-based learning technologies CoCalc, Wolfram Alpha, or the study of additional topics related to the topic of the course, but not considered due to time constraints on learning discipline. Researching the problem develops the ability to conduct research, the ability to use hardware and specialized cloud services, obtain additional data and interpret them, the ability to work independently, all together are components of professional competencies formed at the appropriate level of a successful future statistician.

The means of forming the professional competencies of future bachelors of statistics, which are specified in the presented methodology using cloud-based learning technologies, include CoCalc and Wolfram Alpha, textbooks or teaching materials, as well as computers (laptops, tablets, smartphones) with an active connection to the Internet.

The result of the proposed methodology is the formed professional competencies of future bachelors of statistics at a high level, as well as the successful application of skills to use CoCalc and Wolfram Alpha to perform practical work in the professional field.

4 CONCLUSIONS

Therefore, according to the research, the most appropriate, convenient, and effective cloud-oriented learning technologies for the formation of professional competencies of future bachelors of statistics by the manifestation of all criteria are cloud-oriented learning technologies CoCalc and Wolfram Alpha. The general structure of the methodology of using cloud learning technologies for the formation of professional competencies of future bachelors of statistics is described. In the future, it is planned to describe in more detail the individual components of the methodology of using cloud learning technologies for the formation of professional competencies of future bachelors of statistics, in particular the forms of use and forms of organization of the educational process.

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Introspection as a Condition of Students' Self-management in Programming Training

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Keywords: Introspection, Self-Management, Students, Independent Work, Training in Programming.

Abstract: The paper is devoted to the study of types of managing the student's educational activity. The educational discipline "Practicum of problem solving in informatics" for students of third year study, future teachers of informatics have been chosen for realising pedagogical conditions of computer-oriented management of students' educational activity. Progressive turn from direct management through co-management, subsidiary management to self-management was the main idea of designing the courseware. The information and communication educational environment has been based on the platform of learning management system Moodle. The Workshop elements of Moodle played the central role in management of students' educational activity. The results of our pedagogical observation and assessment showed the efficiency of suggested approach. Additionally, there were shown the lack of students' competency in time planning and introspection on the base of the experimental data.

1 INTRODUCTION

1.1 Statement of the Problem

Informatisation of the educational process has led to the creation of information and communication educational environment in institutions of higher education and significantly influenced the goals, content, methods and means of students' educational activity, forms of its organization. The use of modern powerful computer tools for implementation of management tasks in educational process means the transition to a new type of management – computer-oriented, which can provide the personalisation and not only serve the achievement of learning goals, but also help the student to become the active participant of such management, that is the subject of self-management. The use of information and communication technologies is connected with developing innovative management practices and introducing these technologies to educational process. There are many theoretical and practical studies in this field, but it remains relevant today.

1.2 Analysis of Previous Research

One of the most fundamental analysis of theoretical and methodological aspect according to the management of the independent learning activity of students of pedagogical higher educational institutions was suggested by Malykhin (Malykhin, 2009). Recently, appropriate methodical systems have been introduced into the practice of the educational process to provide for computer-based management of students' educational activity. Information and communication educational technologies, especially, cloud technologies that transform education have been analysed according to results of the "Cloud Technologies in Education" workshop (Kiv et al., 2020). Lavrentieva et al. (Lavrentieva et al., 2019) have analysed new methods of the organization of students' independent study activities together with the use of ICT and tools.

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Computer-based tools of supporting students' independent experimental activity in the process of learning quantum physics have been proposed by Velychko and Shulga (Velychko and Shulga, 2018). Management of students' educational activity was provided as support in instrument setup, measurements, results processing. Vlasenko et al. (Vlasenko et al., 2019) have designed and are developing an educational site "Differential Equations" to support students' educational activity. The site contains theoretical framework, practical classes, provides consultations online and via e-mail, testing, discussion cases, forum and provides support for the teaching of the course and solving practical problems of research character by students. Podlasov et al. (Podlasov et al., 2017) have proposed elements of blended training in physics at a technical university on the basis of programmed learning (students study new material or fixate their knowledge) in the Moodle system with the help of the element Lesson. Kyslova and Slovak (Kyslova and Slovak, 2016) developed methods of using the mobile learning environment in study of higher mathematics by future electromechanical engineers. These methods are based on the complex application of computer tools: using Google Apps Education Edition (texts, diagrams, links, videos); execution of practical tasks and research with developed models in cloud-oriented GeoGebra and CoCalc environments; application of Drawings for generalization and systematization of concept connections, Forms for testing, CoCalc for task generation. Tools integration was provided with using Classroom, Calendar was used for scheduling training activities. Triakina et al. (Triakina et al., 2018) analysed E-learning instruments for self-education and have suggested the ways of this tools implementation into professional training. Methods and technologies for the quality monitoring of electronic educational resources were analysed by Kravtsov (Kravtsov, 2015). Pinchuk et al. (Pinchuk et al., 2019) stressed flexibility and adaptability of pedagogical systems as principals of a substantial transformation of the education system. Realisation of these principals needs in comprehensive pedagogical diagnostics and prognosis in educational process. A methodical system of computer-oriented management of independent work of future teachers in the process of learning computational methods (numerical methods) was developed by Bilousova et al. (Bilousova et al., 2019). This system is based on the use of specially designed computational models in MathCAD environment and assumes learning management system Moodle to support for management of students' independent work. It should be noted that development of the educational process on the basis of its reorientation to students' self-management their own cognitive activity not only contributes to enhancing the autonomy of students, but also gives the education of personal significance. By determining the individual trajectory of educational and cognitive activity of each student on the basis of the maximum consideration of his individual and cognitive abilities, the necessary prerequisites for the formation of his skills of systematic and continuous professional self-improvement are created. Useful analysis in this direction were suggested by Kruk and Zhuravleva (Kruk and Zhuravleva, 2010). Santos et al. (Santos et al., 2012) suggested a tool for empowering students to reflect on their activity. Special analysis of a way and steps for transforming students' independent work management from direct to self-management was suggested by Bilousova et al. (Bilousova et al., 2020). This theoretical analysis was implemented in training process of future teachers of informatics that gave authors possibility to see binds between students' introspection and competence in self-management. Self-regulated learning were discussed by Nussbaumer et al. (Nussbaumer et al., 2012). They stressed that the cognitive and metacognitive activities are not directly measurable, so the measurable actions should be mapped to cognitive and meta-cognitive learning activities (Nussbaumer et al., 2012). But known results observed in our review are not enough to built completed model of a student for pedagogical prognosis.

1.3 Objectives

The potential of computer-oriented management of students' educational activity is not fully realized, according to the above analysis. It actualizes the study of pedagogical conditions, the introduction of which improves the effectiveness of such management. We should find the methods to contribute students in obtaining better educational results and in acquisition of the active personal position in managing their own independent work. We also need in some approaches to measuring the parameter of the model of a student for pedagogical prognosis and effective choosing appropriate type of management. This task is complex and very complicated, so it can not be solved in a single study. Our work is directed to solving this problem by studying some elementary issues of student model and correlation some its parameters with efficiency of some management type.

The purpose of this paper is theoretical and practical study of introspection as a pedagogical condition of effective computer-oriented management of students' educational activity in information and communication educational environments.

2 THEORETICAL FRAMEWORK

There are various approaches to defining the concept of management in pedagogical systems in the psycho-pedagogical literature. Thus, Markov (Markov, 1978) views management as an organization of purposeful actions, Itelson (Itelson, 1964) sees management as the actions that are directed to achieving a previously set goal. Korshunov (Korshunov, 1987) considers that management is the organization of a process that ensures the achievement of a predetermined goal. Filippov (Filippov, 1980) considers management as the purposeful influence of the subject on the object and the change of this object as a result of influence. Nechaev (Nechaev, 1992) speaks about management as purposeful regulation of processes. In some studies, management is seen as an element of some system that connects all its elements and subordinates them to the goal. Thus, Yakunin (Yakunin, 1988) sees the essence of management in the interaction of the student and the teacher, which is carried out in accordance with the set goals and is aimed at activating the student's activity in the learning process and achieving the required results. We agree with all of the above statements, which highlight certain features of management and confirm the relationship between management and activities. It is also defined by the new interpretative dictionary of the Ukrainian language: "To manage - 1. To direct activity, work of someone, something; be led by someone, something; manage. 2. To direct the course of a process, to influence the development, the state of something" (Yaremenko and Slipushko, 1999). On the basis of this analysis of pedagogical research on the problem, the essence of managing student's educational activity is determined as realization of interaction of a student and a teacher, which is aimed at activating student's activity in the educational process and achieving the educational goals. As a result of this interaction, the social and cognitive experience of the student changes, which acquires the trait of independent, purposeful activity in order to become ready to solve future professional problems.

The development of information and communication technologies creates prerequisites for improving the efficiency of managing students' educational activity in modern higher education process. Given the new role of the teacher as a tutor, a moderator, who provides support to the student in choosing and building an individual educational trajectory, the new quality of management is seen in its variability, coordination of management actions with individual capabilities, needs and requests of the student. This management is directed to help the student to get knowledge and skills according to the curricula, but also to increasing involvement of the student in managing their own educational activity, in the progressive transition from direct management to co-management, subsidiary management and further to self-management. ICT-oriented management of student's educational activity is a multi-stage process (collection of information, statement of objectives, decision-making, implementation of the decision, monitoring and evaluation of results, adjustments) that is implemented with the use of appropriate ICT tools at each stage. Implementing student's self-management with the use of modern, powerful computer management tools means moving to a new type of management – computer-oriented, capable to provide higher quality of management. This new quality can not be proved theoretically, but it was observed in educational process. We have analysed our previous empirical work [hide for peer review] and can highlight the most important features of computer-oriented management of student's educational activity:

- adaptability that is based on detailed data on the level of knowledge and skills required for independent work, as well as on the dynamics of their acquisition;
- flexibility that assumes gradual involving of a student in improving management of his/her own independent work through the transition from direct management to co-management, subsidiary management and self-management on the base of analysis of the accumulated experience of using a certain type of self-management and data on its effectiveness;
- timeliness, which is provided by the opportunity to monitor the process of the task execution and the availability of communication resources, that allows timely and targeted assistance and advice to the student, based on the accumulation and analysis of data on the progress and effectiveness of his educational activity;
- transparency, which involves openness of requirements to the results of the educational activity, criteria for the evaluation, rating indicators of student's educational achievements;
- objectivity in making managerial decisions that is based on objective testing data and tracking the effectiveness of the student's educational activity.

Pedagogical conditions for the effective implementation of the said management in the educational

Table 1: Activities of the subjects of the educational process at different management types on the stage of implementation of the decision.

Type of management			
Direct management	**Co-management**	**Subsidiary management**	**Self-management**
The teacher sets a task for the student	The teacher discusses a task with the student	The student chooses a task from a database	The student formulates a task and coordinates it with the teacher
The teacher sets the methods of the task execution	The teacher discusses the methods of the task execution with the student	The student chooses the methods of the task execution from suggested by the teacher	The student determines the methods of the task execution independently
The teacher suggests necessary resources to for the student	The teacher suggests necessary resources to for the student	The student chooses necessary resources from the given resource base	The student determines the necessary resources independently
The teacher gives the example of the correct operation sequence (detailed instruction)	The teacher gives the common schema of the operation sequence (framework instruction)	The student determines the operation sequence independently	The student determines the operation sequence independently
The teacher provides current correction of the task execution process	The teacher adjusts the process of completing the task, if necessary	The teacher adjusts the process of completing the task, if the student ask him for help	The student controls the task completing process independently
The teacher provides the student with current systematic help	The teacher helps the student, if necessary	The teacher helps, if the student asks	The teacher helps, if the student asks
The teacher gives the pattern of report to summarising obtained results. The student acts according the model	The teacher gives the plan of report to summarising obtained results. The student acts according the plan	The teacher gives the requirements to report and summarising obtained results. The student produces the analysis of obtained results independently	The student coordinates the form of report with the teacher and produces the analysis of obtained results independently

process have been substantiated on the basis of analysis of the new opportunities for managing the student's educational activity:

- designing of information and communication educational environment, which contains variation educational-informative, instructive-methodical, software-instrumental, as well as communication resources for organization and support of the student's educational activity;
- using a system that automates the collection, accumulation and analytical processing of performance indicators of student's educational activity;
- ensuring the readiness of all participants in the educational process to implement computer-oriented management of the student's educational activity.

The above pedagogical conditions was checked in the comparative pedagogical experiment in the PhD thesis of one of the present paper authors. The results of this experiment have proved that abidance of suggested pedagogical conditions contributes increasing the efficiency of computer-oriented management of independent work of future teachers in the process of their natural and mathematical training.

Only comprehensive application of all conditions ensures the effective management. The implementation stage of ICT-oriented student's educational activity management is the key stage, when the student actively takes part in this management as the person of educational process. Understanding the character of interconnections between the teacher and the student (table 1) is very important for developing the flexible management based on different types of management (direct management, co-management, subsidiary management, and self-management) (Bilousova et al., 2020).

3 METHODOLOGY OF EMPIRICAL RESEARCH

We have realised the above approach to management of students' educational activity in the students' training in programming. The information and communication educational environment has been based on the platform of learning management system Moodle. It contained built-in communication resources as well as reference to educational-informative resources and instructive-methodical materials according to programming the basic algorithmic constructions for organization and support of the students' educational activity.

The first stage of empirical work was realised in practicum of problem solving in informatics for future teachers of informatics. 10 students took part in this work. The software-instrumental resources (Eclipse environment and the tools of common information technologies) were present at every students' computer. The leading information channel was the interactive lectures, where the elements of programs have been analysed in details. The educational activity of the students at this interactive lectures were managed directly, because the students did the notes in the form of parallel development the suggested and analysed algorithms as Java programs. Interactive parts of this lectures involved some students in co-management of educational activity, but some of them were passive and continue execute the tasks in direct management regime, using the ready fragments of code and orientating only at the teacher's commands in the time planning. The students' notes in the form of developed and tested programs became the instructional materials for management students' independent activity in problem solving.

There were created 5 Workshop elements of activity in the course in Moodle environment and suggested 5 series of individual tasks for each student according to the such topics: linear algorithms; branching; cycles; one-dimensional arrays; two-dimensional arrays. There were 10 variants of tasks, so each student obtained individual variant. The example of full task series for one of these variants is shown in table 2. Every of this series contained three tasks of different levels. Student should complete one of this task for passing or all tasks for high grade. The first task assumed the direct (but distance) management of students' educational activity, because this task was very similar to the one was analysed at lecture. The second task assumed the direct or co-management. This task was based on some of analysed algorithms but was not fully similar. Students could solve this problem using only the lecture notes (direct management). But sometimes students needed in additional information for solving the problem. They could ask the teacher or colleagues personally or using the built-in tools of Moodle (co-management) as well as to use some additional information resources (subsidiary management). The third task was difficult and assumed using the algorithmic constructions that were not analysed at lectures. Students had to discuss this problem with the teacher (co-management) or independently use the additional information resources (subsidiary management). So, the students independently and intuitively made the decision on using some of above type of management of their own educational activity for each task according to their educational achievements and skills of independent activity.

Students uploaded the results of the tasks execution to the Workshops. It should be the correct program with the author's tests to prove it correctness. The second phase of students' activity in Workshops was to check and grade the works of the colleagues – assessment phase. Only the students, who have executed the first stage of the task and have submitted their works, could take part in the assessment. The assessment process is creative activity, but its management was direct, because the students assessed according to the simple instruction: +1 point, if the program is submitted and perform the required results; +1 point, if the program correctly work with the author's tests, +1 point, if the reviewer cannot suggest any tests to indicate the bugs. Grading of the assessment phase was produced automatically by comparison of student's given grades with other reviewers' grades for corresponding works. Teacher also took part in the assessment as a reviewer with weight coefficient of 10. This procedure represents our method of evaluation. So, the student's grade for submission is a sum of the grades for three tasks and the grade for each task is from 0 to 3 as it was described above. The student's grade for assessment was evaluated automatically with a built-in algorithm of learning management system Moodle for the Workshop element.

The teacher carried out pedagogical observation during the course. Students, who did not submit their works in time, passed each task at additional time in the form of discussion of the results with the teacher personally. Such results were not analysed in this study.

There was the final test for future informatics teachers at the end of the course. This final test took place in a classroom at fixed time under the teacher observation. The students were suggested to design three programs of different difficulty levels with using algorithmic elements of different topics. The students, who completely designed the program for the satisfactory level could obtain up to 74 grade point. In case of errors the grade was decreased. When the satisfactory level was passed successfully, the student was suggested with a task for sufficient level (up to 89 grade points). And finally, a task for high level was suggested. Some students could not satisfactory pass this test in fixed time. They had additional at-

Table 2: Example of tasks set for workshops.

Topic	The First Task	The Second Task	The Third Task
Linear Algorithms	Develop a program for calculating the income of a family of 4 people for the specified income of each family member	Develop a program to calculate the rest when buying n units of goods at a price of x_1 dollars x_2 cents, if the box office submitted y_1 dollars y_2 cents	Develop a program to calculate the amount of money to buy n CD disks, if each individual CD disk costs x hryvnia, and a box of ten CD disks is sold at a discount of y percent
Branching	Develop a program to test knowledge in the history of science according the following scenario: 1) the computer submits the task: "Year of birth of Serhii Oleksiiovych Lebediev – an outstanding scientist, under whose leadership the first computer in the continental Europe was built"; 2) the user enters the answer as an integer number; 3) the computer compares the user's answer with the correct one (1902) and informs the user about the result of the check.	Develop the program which on the set air temperature recommends clothes: • less than minus ten – "coat"; • not less than minus ten but less than plus ten - "jacket"; • not less than ten but less than eighteen – "sweater"; • eighteen and above – "does not matter"	Develop a program that determines whether the brick will pass into a rectangular hole, according to the specified size of the hole (a,b) and the brick (x,y,z). Input may be not sorted in ascending order.
Cycles	In the treasury of the fairy kingdom are jugs of living water. All jugs are numbered sequentially. The amount of water in each jug is determined by the magic formula $\frac{i^2+1}{2i}$, where i is the number of the jug. Develop a program that for given numbers i_1 and i_2 finds the total amount of water in the jugs from i_1 to i_2 inclusive.	For n numbers entered from the keyboard, compare the count of positive and negative numbers	For n numbers entered from the keyboard, find the length of the maximum series of numbers that are ordered in ascending order. Do not use the array
One-Dimensional Array Processing	Replace the surnames "Danko" with "Tanko" in given array of surnames	Delete items that are equal and next to each other from given array, which contains a list of company names	Two arrays of surnames are specified. Elements with the same index define the ancestor – descendant pair. Develop a program that identifies all the ancestors of a person by a given surname and writes their surnames to a new array in chronological order
Two-Dimensional Array Processing	Replace all negative elements of the 2D array with zeros	A square table is specified, each element of which determines the distance between cities. Assume that there are no errors in the table. Find pairs of cities with the minimal distance between them.	A rectangular table is given: the number 1 indicates land, and the number 0 indicates water. Determine the number of islands. Assume that from one cell you can go to another "by land" if they are located next to each other vertically or horizontally.

tempts, but only the results of the first attempt were used in the present study.

The second stage of our empirical work was realised in the course "Algorithms and data structures" for future bachelors in Computer science (Software and applications development and analysis). We used the same series of tasks that was suggested to students by Workshop elements in Moodle personal learning environment. The kind of grading was the same as one on the first stage: +1 point, if the program is submitted and perform the required results; +1 point, if the program correctly work with the author's tests, +1 point, if the reviewer cannot suggest any tests to indicate the bugs. Students took part in the grading together with a teacher, it was anonymous peer review process. This work supported developing students' skills in introspection and promoted them to self-management of their own independent work. The analysis of students' review used in this paper to describe binds between quality of such grading, quality of submissions and student's introspection competence.

The pedagogical environment was essentially differ from the one at the first stage because of different educational programs and influence of the COVID-2019 pandemic. Microsoft Visual Studio (C++) was used as the software-instrumental resources. All students solved these problems out off classroom. There were only review lectures and one practical work in class rooms, because COVID-2019 pandemic have started. So the students have not been equipped with examples of solving similar problems, but they had some experience in programming as a result of passing previous courses according the curricular. We can believe that management of students' independent work in problem solving was subsidiary or self-management. Personal learning environment in Moodle was the key component of the courseware. The leading information channel was the interactive lectures realised in Lesson element of Moodle (direct management with answering short questions after each portion of information) as well as the teacher consultations in built-in messenger (co-management). The system of pedagogical diagnostics was based on analysing workshop submissions and assessments, built-in lecture testing, results of final tournaments in programming. The material on base algorithms for linear data structure processing (linear algorithms, branching, cycles, one-dimensional arrays processing, two-dimensional arrays processing) covers only first module of the course in contract with the curricular of future teachers of informatics.

There were not the final test for future computer science bachelors because of COVID-2019 pandemic. So we needed another values for comparison the students' educational achievements with characteristics being investigated. We used the results of automated testing during the students' work with Lesson element in Moodle. There were 6 of such interactive lectures in the course (not only for the investigated topics). The questions were both theoretical and practical. A student could try to pass the lecture so many times as he/she wanted. We used the highest test results for each lecture as the test value. The average of these test values across the course were calculated to obtain appropriate characteristic for each student. Also the average time that students used for lecture studying and testing was analysed as an additional characteristic of student's style of learning.

Students had possibility to pass the course without taking part in suggested workshops by independent studying correspondent material using the Internet and taking part in tournaments to show their competences. 11 students – future bachelors of computer science have taken part in the workshops.

4 RESULTS AND DISCUSSION

4.1 Future Informatics Teachers Introspection

Correlation between students' final test results and students' average grades for submitted works has been evaluated to estimate the validity of our assessment tools on the sample of future teachers of informatics (figure 1). Coefficient of Pearson's correlation is 0.70 that is statistical significant at the 5% significance level.

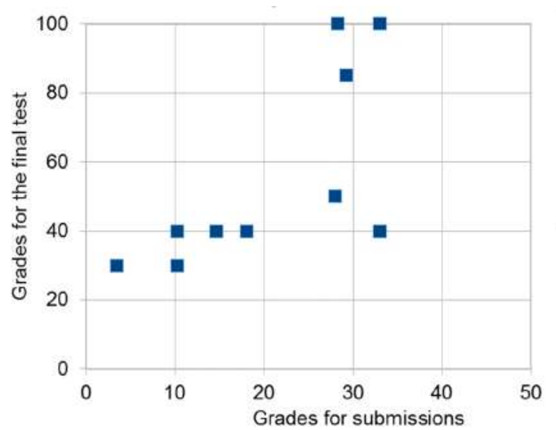

Figure 1: Correlation between students' final test results and students' average grades for submitted works (future informatics teachers).

Correlation between the quality of tasks execution by students and their skills in assessment seems to be very good for 7 students (figure 2), but 3 students with highest results of tasks execution did not take part in assessment, so we cannot prove this correlation statistically, the size of our sample is not enough. According to our pedagogical observation, some students did not take part in the assessment because of their mistakes in time planning.

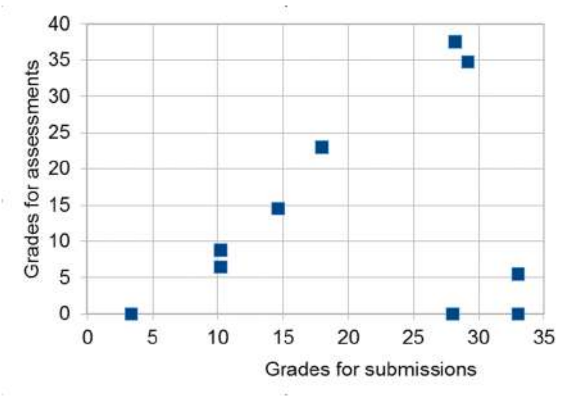

Figure 2: Correlation between students' average grades for assessment and average grades for submitted works (future informatics teachers).

Not all students were able to maintain the proper pace of educational activity progressing from the first topic to the last (figure 3). Some of them worked effective only in the begin, when direct instructions were full enough to execute some tasks. Because of low motivation and lack of elementary skills in self-management, they did not switch to co-management by their own initiative. These students did not submit some works in time and then passed the tasks at classes with personal participation of the teacher in the process of programming and time planning. So we should develop a mechanism for preventive diagnostic of students' skills in self-management and timely turn them to direct management of educational activity. Also, we see that direct management is an easier way of educational activity for some students. This way seems more comfortable for them. So, we should develop special methods to motivate this category of students for their progressing to self-management of the own educational activity. But other students actively used communication and additional sources to solve problems and did not decrease the level of submissions, when progressing to next, more difficult topic.

As expected, the most difficult for the students was the third task in each Workshop, the least difficult – the first task (figure 4). Analysing the structure of student works according to given criteria (figure 4), we can conclude that the most problem for students was not the development of the program but provident that it works correctly. The author's tests often were absent or incorrect. The program, if present, often was correct, but sometimes the reviewer's tests could find some bugs.

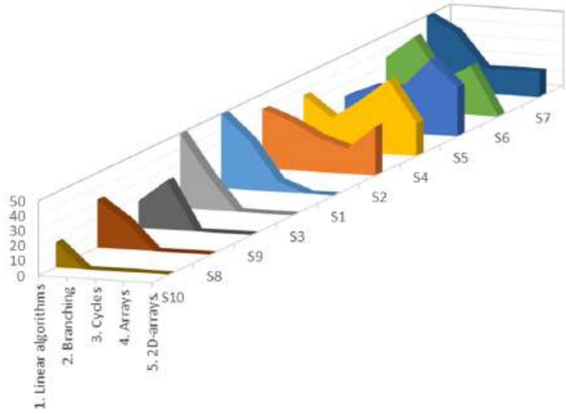

Figure 3: Students' progressing from the first topic task (Linear algorithms) to the last (2D-arrays). Students' names are shown as S1-S10. Vertical axis shows students' grades for submission. The maximum possible grade was 50 (future informatics teachers).

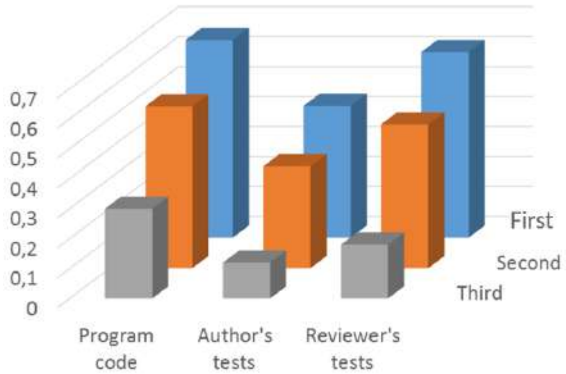

Figure 4: Part of submissions that satisfy to the criterion (program code, author's test, reviewer's test) on each task (first, second, third). This part was calculated as average for all 5 Workshops (future informatics teachers).

The analysis of the structure of students' works showed that the students' competency in introspection was not enough. In our opinion, the introspection is one of the leading elements of self-management competency. So the educational tasks should always content some sub-tasks on introspection.

Summarizing the result of our experience in combining of different types of management of students' educational activity, we can conclude that providing the above pedagogical conditions gave us possibility to improve the educational process in “Practicum of problem solving in informatics”. Flexible management of students' educational activity with timely turn from the direct management to co-management and subsidiary management with return, when needed, supported the efficiency learning. In despite students' involving in practical labour out of the educational process, the goals of “Practicum of problem solving in informatics" were achieved.

4.2 Future Computer Science Bachelors Introspection

According to curricular future computer science bachelors had additional training in programming and their results were higher (see figure 5). Their competence in introspection was enough to produce testing of own programs in comparison with future informatics teachers. But sometimes students did not see the error in these tests. So the grades for auto testing were lower than one for submissions: the program works and processes some data with errors, this errors are shown by author's test, but the author submits this test and does not see the errors. To find errors that were not shown by author's test was more difficult. But reviewers found these errors, so grades for review's tests were less. This situation is well known in practice of software developing. Therefore, introspection is one of the necessary soft competencies in this field of business.

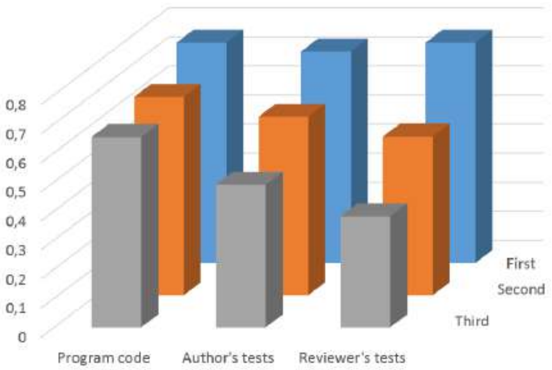

Figure 5: Part of submissions that satisfy to the criterion (program code, author's test, reviewer's test) on each task (first, second, third). This part was calculated as average for all 5 Workshops (future computer science bachelors).

We did not observe a tendency to decreasing students activity and quality of submissions with increasing the difficulty of tasks (see figure 6).

In our opinion, this fact characterises that students of this sample do not need in direct management of their independent work and tried to solve complicated problems. On other hand they, may be, were not so careful with "simple" problems.

Figure 7 shows correlation between students' grades for assessment and submissions. This grades was calculated as average of corresponded grades for all 5 workshops. All grades are shown in relative values, so diapason of values is from 0 to 1.

The above analysis shows that introspection is one of the key integral characteristic of the student's learning style. It is important element of pedagogical conditions for high levels of student's independent work management up to self-management. More over, the introspection is a part of professional competences of software engineers. We can see positive correlation between the introspection signs and the signs of problem solving in software developing. Despite satisfactory level of introspection that was observe at our study we should stress that any courseware needs in special tasks for developing and monitoring students' introspection.

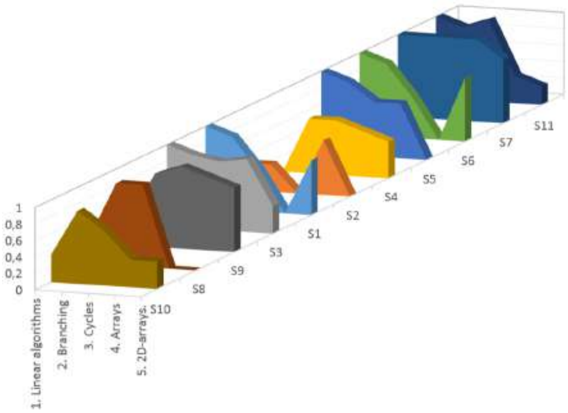

Figure 6: Students' progressing from the first topic task (Linear algorithms) to the last (2D-arrays). Students' names are shown as S1-S11. Vertical axis shows students' grades for submissions. The maximum possible grade was 1.0 (future computer science bachelors).

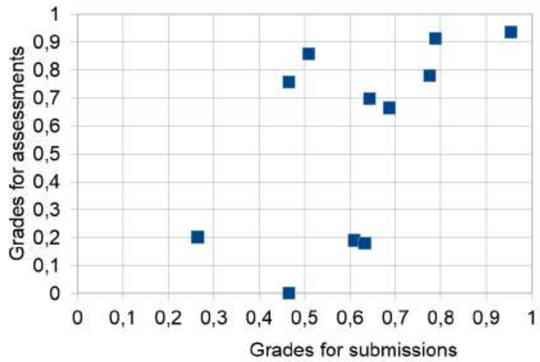

Figure 7: Correlation between students' average grades for assessment and average grades for submitted works (future computer science bachelors).

We can conclude that the level of students' independent work management was enough high as a result of providing the theoretically grounded pedagogical conditions in in the teaching the course "Algorithms and data structures". Realisation of distant learning components in our courseware gave us possibility for monitoring and timely change the levels of learning activity management for each student and supported students' self-management when COVID-19 pandemic has influenced on the educational process.

4.3 Correlation Between Introspection and Success in Directly Managed Learning

Direct management of students' educational activity (independent work) was organised at studying new material with Lesson elements of Moodle learning management system. There were suggested 6 such lectures: "Graph processing algorithms (data representation)"; "Graph processing algorithms (data analysis)";"Optimization problems on graphs"; "Basics of tree data structure"; "Application of tree data structure"; "Fundamental algorithms and their construction". This lectures assumed a student to read educational material by short portions and answer corresponding questions online. The lecture work was graded on the base of student's answer correctness. Students attempts to listen the lecture material and answer the question were not limited. The highest grade for answering was used in the course grading system. The time of each attempt was stored. So we have possibility to check was there some correlation between students' results in creative work with their programs developing or testing (high levels of students' independent work management) and results in lecture studying that was managed directly.

Figure 8 shows that correlation between students submissions and their lecture testing result are absent. Direct management provided high level of students' mastering in educational material despite of their results in program developing. Moreover, some students with high mastering in programming did not paid attention enough to obtain the maximum grade for this kind of educational work. We can see similar picture when analysing the correlation between students' grades for assessment and their lecture testing result (figure 9). There are not correlation between students' grades for assessment and the average time that students used to complete lecture with built-in tests also (figure 10). So we can conclude that introspection did not influence at the efficiency of direct managed educational activity.

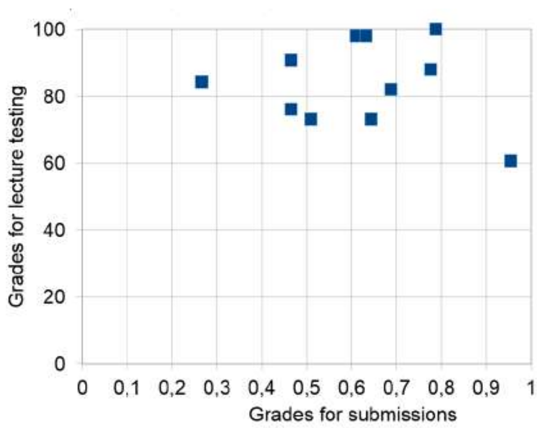

Figure 8: Correlation between students' average grades for submissions and average of the highest grades for lecture testing (future computer science bachelors).

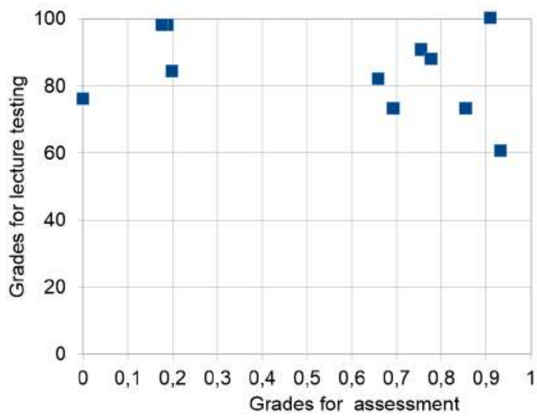

Figure 9: Correlation between students' average grades for assessment and average of the highest grades for lecture testing (future computer science bachelors).

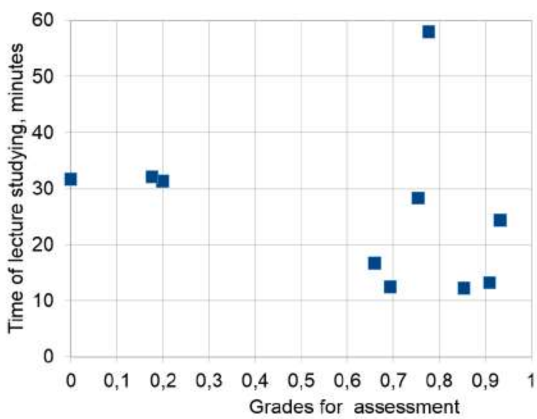

Figure 10: Correlation between students' average grades for assessment and the average time that they used for lecture studying and testing (future computer science bachelors).

5 CONCLUSIONS

Our pedagogical observations during the presented empirical work showed that providing the theoretical grounded pedagogical conditions of management of student's educational activity led to improving the educational process in the field of programming. We implemented flexible management of student's educational activity with timely turn from the direct management to co-management and subsidiary management. We observed that such methods supported the efficiency of learning.

Analysis of obtained experimental data in context of our theoretical framework has given the base for such conclusions:

- signs for student's introspection as a characteristic of his/her learning activity was suggested: 1) student's success in testing there own programs; 2) student's success in testing and evaluation of the program code of other participants of the educational process – our pedagogical observations showed that introspection measured by this way positively influenced to students self-management efficiency;
- students' competency in introspection is important as for self-management of their independent work as for solving practical tasks in the field of programming, so it should be improved, and educational tasks should always content some subtasks on introspection;
- some students are not ready to manage their own learning activity, sometimes the type of management of student's educational activity should be timely turned back to direct management – using direct management of learning activity for students with low competence in introspection gave them possibility to master the educational material;
- students' introspection did not influence on efficiency of their learning activity under direct management; more over, some students with high level of introspection did not carry out the tasks under direct management enough carefully; so the improving management of students' independent work from direct management through comanagement and subsidiary management to self-management is the important task of educational process.

Further work in the field of computer-oriented management of students' independent educational activity we see in developing new methods of students' progress from direct management through comanagement and subsidiary management to self-management in information and communication educational environments, in introduction of these methods into various educational disciplines as well as studying pedagogical and psychological conditions to increase students' motivation for self-management of own educational activity.

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Digital Educational Environment of Teachers' Professional Training in Pedagogical University

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Abstract: Modern tendencies of development of digital educational environment of university and model of its introduction in pedagogical university are considered. The article analyses the concept of the educational environment, its components and features of the structure. The concept of digital educational environment is introduced. The components of digital educational environment for the teachers' professional training of the Ternopil Volodymyr Hnatiuk National Pedagogical University (TNPU) are described: technological, didactic and social. The features of this environment such as: information saturation and openness, digital transformation, social practices and cooperation are considered. The study of the effectiveness of digital educational environment for teachers' professional training was carried out on the basis of TNPU. In total, 432 masters of all specialties of the University participated in this study. The study used the method of expert assessments for statistical processing of results. The study was conducted to determine the level of importance of all indicators of each component of the digital educational environment. The results of the study illustrate the significant changes in the technological and social components of the university digital educational environment, which have a significant impact on the teachers' professional training.

1 INTRODUCTION

The key problems of the higher pedagogical school of today are the lack of manifestation of the cultural and historical context for the higher school, which sets the framework for higher education. The rapid development of educational management leads to process-oriented management of an educational institution and the emergence of terms such as "educational space", "educational landscape", "educational field", "educational environment".

The new educational perspective on the development of the contemporary educational environment requires the reorganization of many aspects of future teacher training.

The transition from traditional educational models to modern ones envisages a change in the organizational, cultural, institutional dimensions, management models and digital educational environment for the teachers' professional training.

Given this, there is a problem of resetting all pedagogical education, rethinking the role of pedagogical universities and other educational institutions in society, analysis of the educational environment of teachers' professional training in order to improve their quality of knowledge.

2 RELATED WORK

The analysis of the literary sources shows that the issues of formation of the educational environment are an important component of the training of modern specialists both in Ukraine and abroad.

The educational environment is traditionally defined as learning, which depends on various environmental factors, a set of objective external conditions, factors, social objects (Bondarenko et al., 2020; Horbatiuk et al., 2021; Dotsenko, 2021; Kyslova et al., 2014). It is a system of influences and conditions of personality formation, as well as opportunities for its

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development, which are contained in the social and spatial-subject surroundings (Hiemstra, 1991). The educational environment is a contemporary temporal, spatial and social situation of learning, which consists of many different educational spaces of different levels, which have educational potential and interact in one way or another. In this environment, the interaction of different levels of the education system and personality happens and the corresponding cultural context is also included (Mandl and Reinmann-Rothmeier, 2001). As a result of a detailed historical study, Spivakovsky et al. (Spivakovsky et al., 2019) have determined that the most promising model for building an educational environment is a hybrid model. Glazunova and Shyshkina (Glazunova and Shyshkina, 2018) have been confirmed these findings for the case of university cloud-based learning and research environment.

Panchenko (Panchenko, 2010) determined that modern specialists should be able not only to use, but also to model and create an educational environment.

Today, the following structural components of the educational environment are distinguished:

1. Physical environment – the room, its design, size and the spatial structure of the training classrooms.
2. Human factor – the university contingent structure, its influence on the social behaviour of students, the quality of lecturer training, etc.
3. Training program – the nature of training programs content, technologies of training, style and methods of training, forms of educational activities, the nature of control (education-ua.org, 2017). The components of the educational space are united by certain ideas and values.

The main features of the educational environments that characterize the new millennium have been determined by many researchers (OECD, 2009; Kalimullin and Islamova, 2016; Pottert, 2004). They point out that the university educational environment should include such components as the information and communication environment, the research environment, the organizational and management environment in accordance with the principles of intensity, psychological comfort and democratic possibilities of individualization of learning, openness and accessibility of information resources.

In most studies, the educational environment is described in terms of "educational institution efficiency" as a social system – emotional climate, personal well-being, features of the micro-culture, quality of the educational process. The educational environment has a significant impact on students' learning and behaviour. There is a strong link between the learning environment and value components such as students' satisfaction and success. The educational environment defines physical and mental self-feeling and motivation and promotes emotional and behavioural responses. Licite and Janmere (Licite and Janmere, 2018), Anderson and Day (Anderson and Day, 2005) analysed the physical environment using three aspects: the planning and size of study rooms, ergonomics and technology, the informal environment and comfort. Describing the ideal auditorium, students noted the importance of technology and comfort role. A broader understanding of the educational environment supposes the inclusion of various communications (press, radio, television, internet resources) created by young people in their own cultural micro-environment.

The work (Professional Standards for Teachers Core, 2007) focuses on the importance of the professional environment of teachers and not only on their professional training. This point should be emphasized, because over the past few years, academic research has forced many experts to assess not only the need to increase teacher effectiveness (for example, through qualification increasing), but also to change the educational environment by improving educational institutions policies, amending laws, and supporting by communities, improving decision-making process, digitizing education that can contribute to quality change in the education sphere.

Modern digitalization means the need to create a new educational environment (Hatlevik and Christophersen, 2013). As digital technology becomes a central part of everyday work, teachers are forced to rethink and transform previous educational traditions through technology. These problems create insurmountable requirements for universities to develop teachers' professional training strategies in the context of mastering digital pedagogy and the digital educational environment (www.regjeringen.no, 2017; Howell, 2012; Kivunja, 2013; Stommel, 2014).

3 RESULTS

3.1 The Structure of Educational Environment

During the research the following methods were used: analysis of scientific and methodological and technical literature in the field of educational environments, state standards of higher education. In the course of the experimental research, the methods of observation, questioning and expert assessments were applied. The questioning of the respondents was conducted according to the methodology of expert assessments, with further processing of its results using the methods of mathematical statistics.

Analysing the views of various scientists about the particularities of the educational environment (Lund and Hauge, 2011; Roth, 1999; Day, 2009), we introduce the concept of digital educational environment as a way of integrating and adopting many of its dimensions. In our study, as the concept of "digital university educational environment" we will consider systemic formation, which is a sociocultural and digital surroundings of the subject of learning, which includes technological, didactic, social components that are able to provide quality professional training for teachers.

Such subjects (involved in the process of creating educational values) as lecturers, students, undergraduates, graduate students, educational institutions, organizations, scientific centres are important in digital university educational environment for teachers' professional training.

Transformation of education is a modern stage of its informatization (Fedorenko et al., 2019), which involves saturation of educational space with appropriate digital devices, tools, systems and electronic communication between them, which allows the interaction of virtual and physical, i.e. creates a digital educational environment (Iatsyshyn et al., 2019, 2021; Kuzminska et al., 2019; Leshchenko et al., 2021; Morze et al., 2021; Morze and Strutynska, 2021; Pikilnyak et al., 2020; Petrenko et al., 2020; Pinchuk et al., 2019; Trcek, 2019).

Let us consider the components of the educational environment which were forming at the Ternopil Volodymyr Hnatiuk National Pedagogical University (TNPU) in recent years in the context of teachers' professional training (figure 1).

The **technological component** of the digital educational environment for teachers' professional training was provided through the creation of a digital environment for the university. The University digital environment infrastructure is a system of software, computing and telecommunications tools that implements the providing of information, computing, telecommunication resources and services to all participants in the educational process. Various tools have been integrated into the university digital environment, which enrich the educational process. In terms of infrastructure this environment is based on the use of university LMS, cloud-based learning environment (CBLE), university digital repository, Web 2.0 services. Kuzminska et al. (Kuzminska et al., 2020) found 4 main components that group all the factors of the digital educational environment into such areas of focus as IT infrastructure and resources' provision, students' and teachers' digital competencies, scientific and educational communication between the students, teachers, and stakeholders, and educational process organization (Kuzminska et al., 2020).

The effectiveness of CBLE in teaching and research has been investigated and tested in (Spirin et al., 2016, 2019).

We consider that indicators of **technological component** development are:

1. **University network and Internet access**. TNPU provides access for students and lecturers from anywhere on campus to the resources of educational environment and the Internet. Local wired and wireless technologies have been used for this purpose. All resources are accessed using a single authentication data.

2. **Learning Management System and courses**. An advanced learning management system is functioning at the university. All subjects that are studying by students have relevant e-courses in this system. In total, more than 600 courses have been developed by lecturers. Practically all kind of students' activities are recorded in this system.

3. **Cloud services and laboratories**. Since 2012, the lecturers of Computer Sciences Department and Methodology of Its Teaching have been working on the deployment of a cloud-oriented learning environment.

   Today, it operates according to a hybrid model and integrates many services of public and private platforms. Significant computing power was required to deploy cloud infrastructure. Due to the high cost of server equipment, it was decided to use ordinary components for personal computers. As a result, a corporate cloud was designed, installed, and configured. The free Apache CloudStack platform was used to solve this problem. It provides the deployment of the corporate cloud according to the most functional model "Infrastructure as a service".

   In general, the physical infrastructure of the corporate cloud has the form shown in figure 2.

   It now operates according to a hybrid model and integrates many services of public and private platforms. CBLE provides unified, ubiquitous and secure access to file and computing resources (repositories, virtual computers, and networks). Cloud infrastructure provides management of educational resources, aggregation of computing resources, knowledge sharing services, increasing

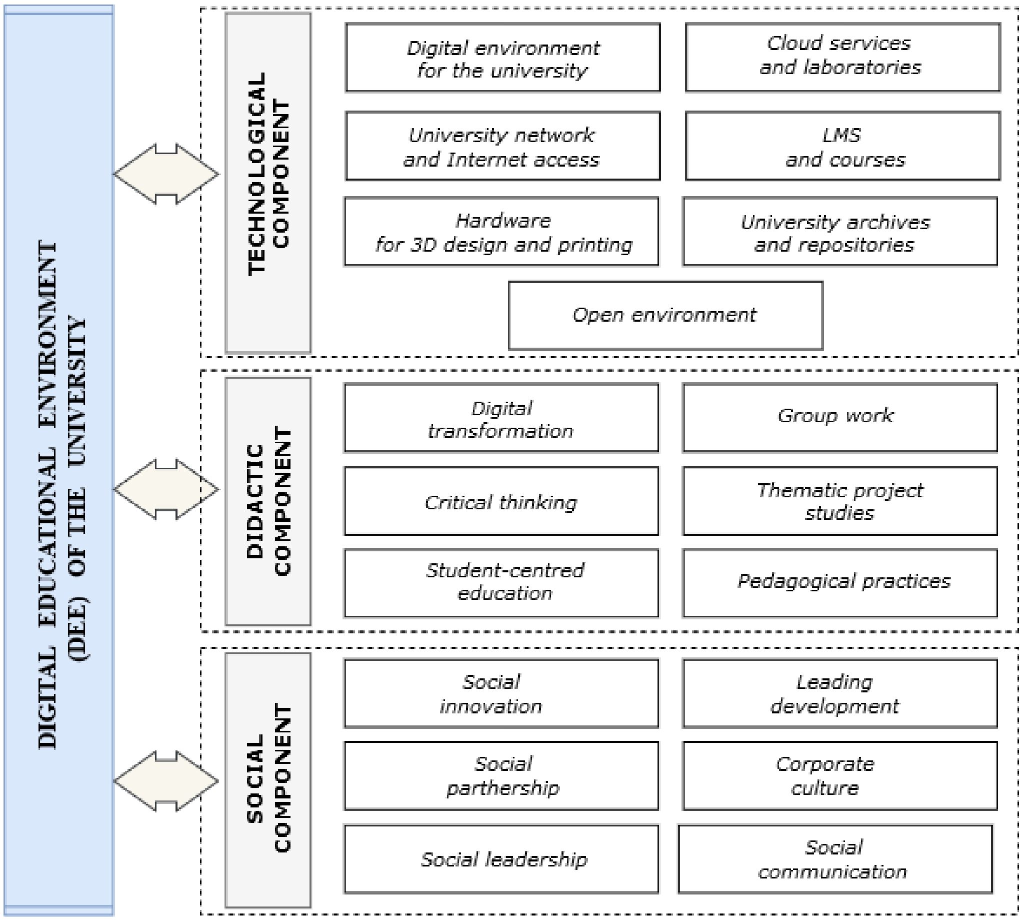

Figure 1: Transformation model of the Digital educational environment (DEE) of the TNPU.

the flexibility of their use by participants in the educational environment.

4. **Hardware for 3D design and printing**. Within the frame of work of STEM-centre (Balyk et al., 2019) promising technologies of 3D-modeling and 3D-printing, technologies of virtual and augmented reality, technologies of the Internet of things, robotics are being implemented at the University. These technologies ensure the execution of innovative projects through the formation of tool environments, the use of project management services. Work on educational projects (for example, a project on 3D-reconstruction and 3D-printing of the destroyed historical castles of Ternopil region) takes place inside a technologically equipped modern educational environment.

5. **Open environment**. An open, non-formal learning environment with lecturers and students has created at the University. The traditional academic hierarchy is gradually being replaced by an approach where students are respected as junior colleagues, and their opinions are appreciated and encouraged by more experienced colleagues. Such teaching is based on modern didactic approaches such as personality-oriented and synergistic. The technological basis of open education at TNPU is modern digital technologies, in particular cloud. This approach encourages dialogue and collaboration between students and lecturers, and creates new opportunities for the development of up-to-date professional training for future teachers.

6. **University archives and repositories**. The University has implemented a system of digital archives. The TNPU Institutional Repository contains materials published by lecturers, such as: monographs, books, manuals, articles, abstracts. Some faculties have digital archives for educational purposes. In addition to the materials of lecturers, they contain the results of students' learning – materials of practices, articles of students, master's works, etc.

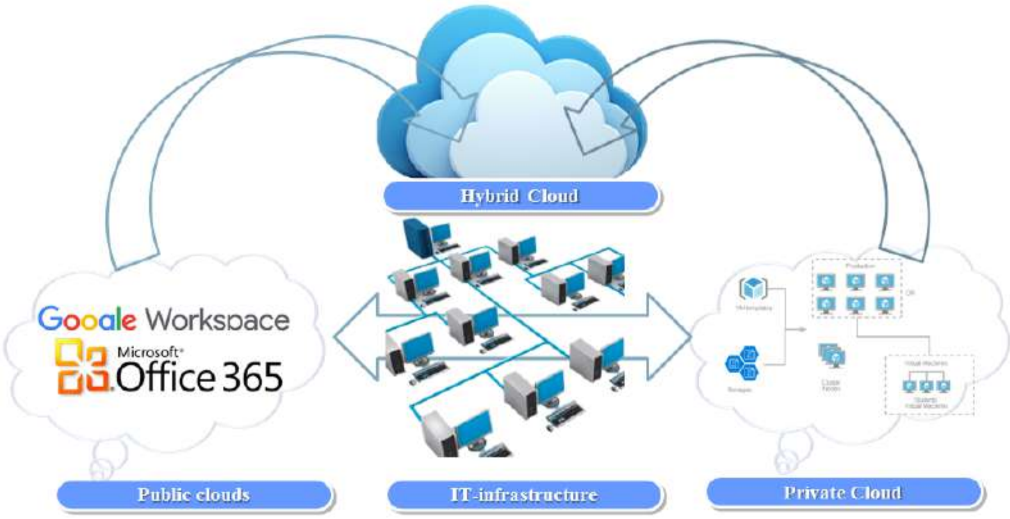

Figure 2: Scheme of the university corporate cloud.

Among the important components of the digital educational environment of the university should be distinguished didactic, which includes the structure of students' activities, teaching style, nature of control, forms of study, the content of study programs. For example, the professorial and teaching staff of TNPU pays special attention to the modernization of educational programs in the context of the tasks of the New Ukrainian School through:

- implementation of a competency, personality-oriented approach in pedagogical education;
- formation of managerial skills for effective activity in the conditions of real autonomy of educational institutions;
- providing practical training through continuous pedagogical practice of students at different educational institutions.

In TNPU, the didactic component of the digital educational environment for future teachers' professional training is characterized by digital transformation, student-centred education; using:

- thematic project studies;
- critical thinking;
- group work;
- social practices.

Let's take a closer look at these efficiency indicators of the **didactical component** for digital educational environment:

1. **Digital transformation**. The digital transformation of the university educational environment is a series of coordinated steps and changes in the information infrastructure, in the digital culture of lecturers and students. This makes it possible to embody new educational models, including digital pedagogy, and transform the activities of the university, aiming at value propositions and strategic directions for the development of modern society.
2. **Group work**. Group work is characteristic of many university disciplines. Its purpose is for students to practice teamwork in small groups, as well as to develop problem-solving and leadership skills. Group work is an important aspect of future teacher training with aim of real professional situations modelling.
3. **Critical thinking**. Critical thinking is encouraged in all activities at the university. At seminars, workshops, laboratory work the students analyse and present solutions to problems and tasks. Theoretical concepts are tested in practical situations, and practical experience is used to develop and enrich the theory.
4. **Student-centred education**. Studying at TNPU is student-centred. There is great support from educators, lecturers play the role of facilitators, helping students understand the content of the course. The focus is on giving students the opportunity to develop their critical and analytical thinking skills, self-study, group work, problem-solving and leadership skills to prepare them for careers.
5. **Thematic project studies**. The teaching methods used in university study focus on critical analysis of course content using real cases where possible. Invited teachers and speakers from schools, local authorities, and public organizations participate in

the educational program to further link research with the professional environment.

6. **Pedagogical practices**. Much of the learning process takes place outside the classroom when students apply acquired professional competencies in real-life situations while undergoing pedagogical practices. Learning technologies are partly beyond the bound of university classrooms.

Let us characterize the indicators of the effectiveness of the **social component** of digital educational environment of teacher training of the TNPU in the context of exploring ways of improving their professional development.

It is traditionally considered that university education is constructed based on the context of the surrounding reality, the cultural space and the environment in which the education takes place. Therefore, at TNPU the main indicators of the effectiveness of digital educational environment of teacher training in the social aspect are: social innovation, leading development, corporate culture, leadership, social partnership, and social communication:

1. **Social innovation**. In our opinion, the departure from the traditional functions of TNPU and the implementation of innovative ones became important for the professional development of teachers:
   - creation of conditions for the system of qualitative training and professional development of teachers through overcoming the fragmented responsibility of different educational institutions for different stages of becoming and professional development of the educator;
   - transition from "translational" education to "active" based on the implementation of digital technologies, project and competency learning technologies.
2. **Leading development**. The essence of leading-edge development lies:
   - in building curricula and learning programs in the university around cross-cutting topics relevant to a particular public community, a united territorial community;
   - in preparing graduates to organize the life of their local community in accordance with the principles of sustainable and successful development.
3. **Corporate culture**. We consider that not only structural components are the social component achievement of the digital university educational environment, but first of all – corporate culture. The key factor to the success of university education transformation projects has been the formation of a collective subject for change. The corporate culture of the university is based on a system of values that determine the philosophy of its activity, the attractiveness of the university brand in the scientific, educational and contemporary socio-cultural environment.
4. **Social leadership**. Social leadership means:
   - engraftment of innovation as a way of thinking and a key leadership tool;
   - distributed leadership in the development of new educational decisions and educational reforms,
   - formation of teachers, as educators of leaders of the new generation, integral personalities.

   The University promotes the growth of students as individuals through quality professional training of highly qualified professionals and personal growth.
5. **Social partnership**. Digital educational environment at the TNPU serves as a catalyst for a new social reality in the region. The University is an active social partner and an element of the social system. The collaboration and partnership of the university educational environment with various actors of the educational field and the public is developing. Lecturers share knowledge and experience in the educational environment, give the products of their professional and innovative activities in the public usage, participate in volunteer activities, assessments and expertise, and more.
6. **Social communication**. Communication has become a key prerequisite for the creation of new meanings, ideas and projects of the University, organization of applied research at the request of regional companies, authorities and the local community. It is important that the university is open to industry, government and other stakeholders. We believe that the greater the degree of openness of a university, the better it develops. The University successfully builds all necessary for its own existence and development of communications with other entities – authorities, manufacturing companies, civil society institutions.

The process of involving the components (technological, didactic, social) of the educational environment of TNPU in the educational process is shown in figure 3.

The basis of modern innovative teaching at the university is teaching students to solve problems. The problems that the authors propose to solve arise from the life context of a person or a local community. This can apply to any aspect of life: work, study, leisure,

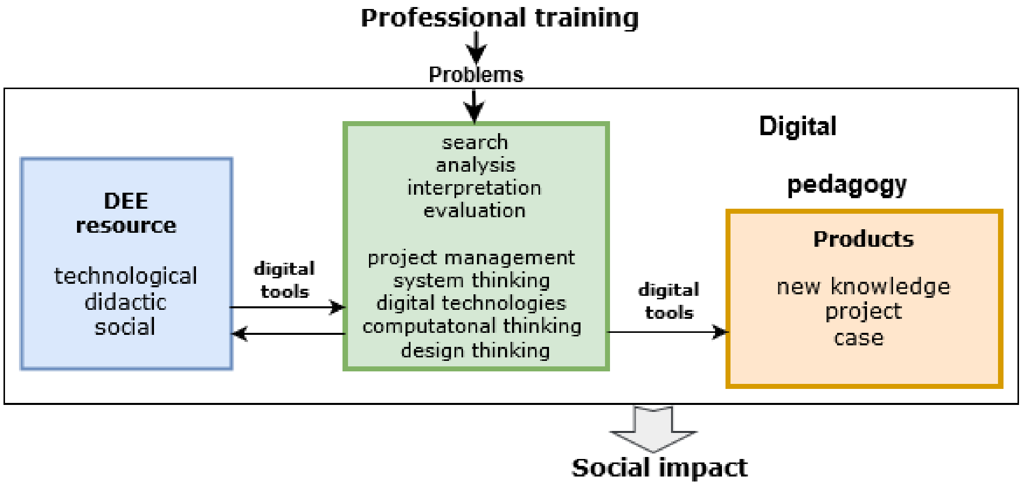

Figure 3: Teacher's training at the Pedagogical University in the context of digital pedagogy.

and so on. The authors began by encouraging students to use digital technology to solve specific problems.

To solve the problem, students must first determine its essence, use the opportunities of the digital educational environment of the university (technological, didactic, social) and the relevant digital competencies. This concerns, first of all, the ability to interpret, understand and express one's creativity through digital tools with the involvement of critical thinking. Students are guided by critical thinking and other technologies (project management, system thinking, design thinking, etc.) as a basis for meaningful and effective participation in solving problems of their community. The conscious use of digital competencies in the process of solving life's problems has an important social impact through the development of a product or solution aimed at solving a practical problem.

Digital pedagogical technologies provide new conditions for students' activities and the formation of their competencies in demand by the digital society and the digital economy.

3.2 The Study on the Effectiveness of Educational Environment Design

In order to determine the effectiveness of the created digital educational environment for the teachers' professional development in 2017/2019, a study was conducted in the form of a survey among future teachers. 432 masters of all pedagogical specialties of the University participated in the survey. We viewed undergraduates as internal stakeholders.

The questionnaire suggested to assess the importance of development each component of the digital university educational environment. In each component we have identified indicators of its development (table 1).

In each questionnaire, we explained to the experts the value of each indicator. To determine the most significant indicators of educational environment development, we used the ranking method. It was to determine the relative importance of the objects under study based on their ordering. A scoring system for assessment was proposed for each component. In each component of the educational environment development, the experts gave points. One point was awarded to the least significant indicator and six points to the highest significant one. The results of the survey are summarized in a table, the columns of which correspond to the codes of indicators, and in rows – sequence numbers of experts (see table 2, where first column is sequence numbers of experts). The table data can be viewed in its entirety by the hyperlink: https://drive.google.com/file/d/1YHaqVE0NSVktz9GlwzqGVGy2HAK7CDWy/view?usp=sharing.

In order to prevent psychological clues that could influence the expert's choice of a certain ranking order, indicators of a certain criterion in the card were placed in alphabetical order.

An expert assessment method was chosen to work out the results of the survey, which was applied to each component of the university educational environment individually due to the independent ranking of indicators within each component.

The most obvious value of assessment an indicator is its total rank, which is determined by all experts ($S_j = \sum_{i=1}^{m} R_i j$, where $R_i j$ is the j-th indicator exhibited by the i-th expert, m is the number of experts).

However, such aggregate rankings will be objective if there is a certain level of agreement between the experts. The degree of such agreement is described

Table 1: List of indicators for assessment of the components of the digital university educational environment.

Component of the educational environment	**Cipher of indicator**	**The name (description) of the indicator**
Technological	T1	University network and Internet access
	T2	Learning Management System and courses
	T3	Cloud services and laboratories
	T4	Open environment
	T5	Hardware for 3D design and printing
	T6	University archives and repositories
Didactic	D1	Digital transformation
	D2	Group work
	D3	Critical thinking
	D4	Student-centred education
	D5	Thematic project studies
	D6	Pedagogical practices
Social	S1	Social innovation
	S2	Leading development
	S3	Corporate culture
	S4	Social leadership
	S5	Social partnership
	S6	Social communication

Table 2: The final results of the study data processing.

	Technological						**Didactic**						**Social**					
	T1	T2	T3	T4	T5	T6	D1	D2	D3	D4	D5	D6	S1	S2	S3	S4	S5	S6
1	5	6	3	4	1	2	6	5	1	4	2	3	6	5	1	4	2	3
2	6	5	4	3	1	2	6	4	5	1	3	2	6	3	4	1	5	2
...																		
432	6	5	4	3	1	2	4	5	6	1	2	3	6	4	1	5	3	2
S_j	2394	1946	1573	1405	770	984	2368	2153	1300	1119	969	1164	2369	1682	750	1736	1593	934
d_j	882	434	61	-107	-742	-528	856	641	-212	-393	-543	-348	857	170	-762	224	81	-578
$S(d^2)$	1810798						1758963						1734814					
W	0.55445265						0.539						0.53118692					

by Kendall's coefficient of concordance W (Legendre, 2010), which is defined as follows:

1. For each indicator, we find the difference between the totals and their average:

$$d_j = \sum_{i=1}^{m} R_i j - 0.5 \cdot m \cdot (n+1) \qquad (1)$$

2. Find the sum of squares of values obtained from relation (1) $S(d^2)$:

$$S(d^2) = \sum_{j=1}^{n} d_j^2 = \sum_{j=1}^{n} \left[\sum_{i=1}^{m} R_i j - 0.5 \cdot m \cdot (n+1) \right]^2 \qquad (2)$$

3. The maximum value of $S(d^2)$

$$S_{max}(d^2) = \frac{1}{12} \cdot m^2 \cdot (n^3 - n)$$

is achieved if all experts rank the criteria (indicators) equally.

4. The coefficient of concordance is equal:

$$W = \frac{S(d^2)}{S_{max}(d^2)} = \frac{12 \cdot S(d^2)}{m^2 \cdot (n^3 - n)} \qquad (3)$$

According to formulas (1) – (3) we find the values of the total ranks S_j, the values d_j, $S(d^2)$ and calculate the coefficient of concordance W for each component of the educational environment. The results of the calculations are presented in table 2.

This value is always between zero and one. If $W = 0$, then there is no correlation between expert rankings, if $W = 1$, then the rankings are completely the same. We get the coefficient $W = 0.55$; 0.54; 0.53 is substantially different from zero, so it can be argued that there is objective agreement between experts.

However, such a value of W is not a criterion for objectivity, since it could be obtained by accidentally setting of ranks one or the other indicators.

The value $m \cdot (n-1) \cdot W$ is distributed by the law χ^2 with $n-1$ degree of freedom. Using the ratio

$$\chi_W^2 = \frac{12 \cdot S(d^2)}{mn \cdot (n+1)}$$

we find the value of χ_W^2 = 1197.62; 1187.77; 1147.36 for the relevant components of the educational environment. Comparing them with the table value for $\vartheta = n-1 = 5$ degrees of freedom and for the significance level of $\alpha = 0.01$, we obtain $\chi_W^2 > \chi_t^2 = 15.1$. Hence, we conclude that there is consistency between experts' findings.

Consider the results of the survey regarding the importance of technological, didactic and social components of the university digital educational environment for teachers' professional development of teachers of the pedagogical university (figures 4, 5 and 6).

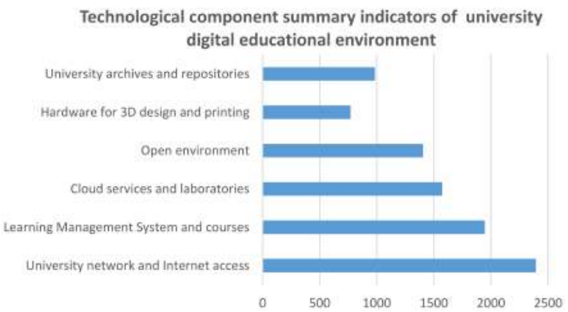

Figure 4: Study results of technological component importance of university digital educational environment in the context of teachers' professional development.

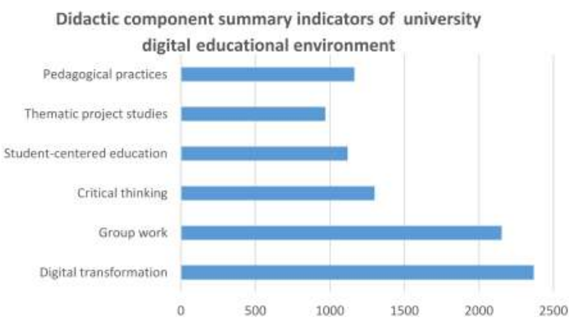

Figure 5: Study results of didactic component importance of university digital educational environment in the context of teachers' professional development.

From the conducted study it follows that:

- of the technological component, the most important for the teachers' professional development are University network and Internet access, Learning Management System and courses, Cloud services and laboratories;
- of the didactic component most important for the teachers' professional development are Digital transformation, Group work, Critical thinking;
- of the social component the most important for the teachers' professional development teachers are Social innovation, Social leadership, Leading development.

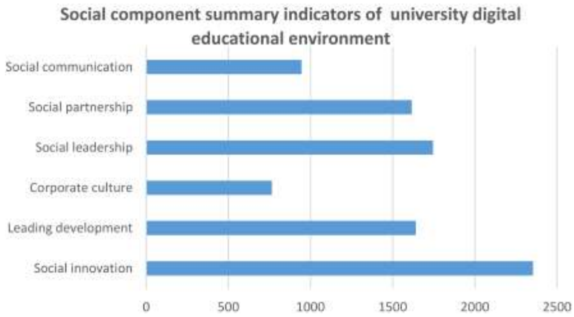

Figure 6: Study results of social component importance of university digital educational environment in the context of teachers' professional development.

To determine the significance degree of each component of the educational environment, we calculated the arithmetic mean of the scores for each indicator (table 3). The indicator was considered positive if the arithmetic mean of expert estimates was at least 3.0.

The significance degree of each component was determined as follows:

- not significant enough: more than 50% of the criteria are negative;
- critically significant: 50% – 55% of the criteria are positive;
- significant enough: 56% – 75% of the criteria are positive;
- highly significant: 76% – 100% of the criteria are positive.

From the conducted study it follows that at the TNPU over the past three years, according to the view of undergraduates, technological and social components of the digital educational environment have become crucial for teachers' professional development.

We tried to investigate the specifics of the distribution of grades depending on the specialty (educational, scientific achievements) of masters.

To do this, we used the Kendall package from the language R. In our table, we added a column group, which tracks the affiliation of students to one of the groups such as:

1 – undergraduates majoring in computer science

2 – masters of natural or technical specialties (physics, mathematics, labor training)

3 – masters of humanities or arts

Table 3: Significance degrees of the university educational environment.

	Technological component						**Didactic component**						**Social component**					
	Indicators																	
	T1	T2	T3	T4	T5	T6	D1	D2	D3	D4	D5	D6	S1	S2	S3	S4	S5	S6
Average value	5.54	4.50	3.64	3.25	1.78	2.28	5.48	4.98	3.01	2.59	2.24	2.69	5.48	3.89	1.74	4.02	3.69	2.16
%	66.7%						50.0%						66.7%					
	Degree of significance																	
	significant enough						critically significant						significant enough					

Function *kendall.global* from R computes and tests the coefficient of concordance among several group of judges through a permutation test. We used it to identify significant group associations.

Here is a fragment of the function *kendall.global* call as follows:

kendall.global(transpose(cr1), group = transpose(groups))

Vector *cr1* contains columns T1-T6 from the data frame. They correspond to the Technological component of the model. The *group* vector contains the numbers 1, 2, 3. They are responsible for grouping. To comply with the syntax of the function, we transposed these vectors using the *transpose()* function.

The results of calculating the concordance coefficients for all three components are shown at table 4.

The result of the function contains the following data:

- W – Kendall's coefficient of concordance;
- χ^2 – Friedman's χ^2 statistic used in the permutation test of W.

To analyze the obtained concordance coefficients, we use the following interpretation of the distribution W (Landis and Koch, 1977; Legendre, 2005):

- 0.01 – 0.20 – poor agreement;
- 0.21 – 0.40 – fair agreement;
- 0.41 – 0.60 – moderate agreement;
- 0.61 – 0.80 – good agreement;
- 0.81 – 1.00 – very good agreement.

Based on the data from table 4, we can draw the following conclusions.

In all three groups for Didactic and Social components, the concordance coefficient W is in the range of 0.41 to 0.60, which corresponds to the mediocre consistency of estimates within each group of experts for Didactic and Social components. Our groups of experts differ little in terms of their readiness to use digital technologies in their learning and future professional activities, but their specialties and orientation of vocational education programs are somewhat different in terms of their ability to assess Didactic and Social components according to relevant criteria. This explains the fact that the concordance coefficients W for all three groups are mediocre.

If we consider the concordance coefficient W for the Technological component, it corresponds good agreement for group 1. This is not surprising, because experts of group 1 (undergraduates majoring in computer science) are able not only to use digital technologies, but also to develop them. Therefore, they are able to assess the Technological component of the digital educational environment of the university according to the relevant criteria more unanimously and more professionally. For groups 2 and 3, the concordance coefficient W for the Technological component is within the same limits as the coefficient W for all groups in Didactic and Social components.

In the RStudio environment using the function *qchisq (p = 0.95, df = 5)* we found the critical value $\chi^2_{cr} = 11.0705$ for degrees of freedom and for the significance level of $\alpha = 0.05$, which corresponds to the value obtained from other sources. As can be seen from table 4, the values of χ^2 calculated by the *kendall.global()* function for all three groups and for each component of the digital educational environment of the university are in the range from 337 to 476, which are significantly higher than χ^2_{cr}. This indicates the consistency of expert assessments within each group at the appropriate significance level.

4 CONCLUSIONS

An analysis of the literature indicates that the term "educational environment" has no unambiguous interpretation. The study proposes to define the design of the digital educational environment as a systemic formation, which includes technological, didactic, social components that are able to provide quality professional training for teachers.

It should be noted that the design features of the modern digital educational environment of the TNPU

Table 4: Concordance analysis for 3 groups.

Statistical indicator	**Group.1**	**Group.2**	**Group.3**
	Technological component		
W	6.609843e-01	4.683366e-01	5.467262e-01
χ^2	4.759087e+02	3.372024e+02	3.936429e+02
	Didactic component		
W	5.636905e-01	5.701720e-01	5.272652e-01
χ^2	4.058571e+02	4.105238e+02	3.796310e+02
	Social component		
W	5.811287e-01	5.189649e-01	5.101356e-01
χ^2	4.184127e+02	3.736548e+02	3.672976e+02

are: openness and information saturation, student-centred education, thematic project studies, social practices, a harmonious blend of pedagogy and digital technology and, as a result, the digital transformation of the entire educational environment.

To identify the effectiveness of the created design of the university educational environment for the teachers' professional development the components of their formation and their corresponding indicators were determined. In the process of research, the undergraduates noted that the greatest influence on their professional development has social (Social innovation, Social leadership and Leading development) and technological component of the digital educational environment (University network and Internet access, Learning Management System and courses, Cloud services and laboratories).

Thus, the activities in the digital educational environment of the university are aimed at the professional development of the individual and the creation of conditions for the socialization of students on the basis of social and cultural values accepted in society.

We consider that in the development of educational environment design of pedagogical university promising directions are such as:

- developing educational strategies and monitoring their implementation and effectiveness;
- realization by the university of its socially transformative role – social and humanitarian innovations, humanitarian paradigm of education;
- organizing effective interaction between the university and external players in order to attract investments to create quality conditions for learning and nurturing successful and competitive human capital.

The perspectives of further research are in experimental testing the created digital educational environment by other internal and external stakeholders like as lecturers, teachers, developers, IT-managers etc.

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Development of Professional Competence of Primary School Teachers of the New Ukrainian School in the Aspect of Foreign Language Teaching

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Keywords: New Ukrainian School, Primary School Teacher, Distance Learning, Internet Resources, Continuing Education, Foreign Language, Professional Competence, Competitive Specialist.

Abstract: The article is devoted to the problems of development of professional competence of primary school teachers in the aspect of teaching foreign languages according to the requirements of the concept of the New Ukrainian School. The analysis and the description of Internet resources as a means of providing the results of foreign language learning in a primary school are made. As knowledge of a foreign language is a social necessity of a contemporary person, the use of Internet resources will help to modernize the study of foreign languages in primary school in accordance with the requirements of the concept of the New Ukrainian School. Acquirement of professional competence of primary school teachers in the method of organizing distance learning is a priority of higher education institutions in the training of future teachers and continuing education.

1 INTRODUCTION

Modern state reforms aim to create a new philosophy of education, which involves changing its paradigm: directions, tasks, content of educational and methodical support, pedagogical mentality. Important state regulatory and legal documents (the Law "On Education" (Verkhovna Rada of Ukraine, 2017), "The State Standard of Primary Education" (MON, 2017), the New Ukrainian School (NUS) Concept (Elkin et al., 2017)), defining the strategy and main directions of education development in Ukraine in the XXI century, set too high requirements for teachers and to the level of his/her personal development. Therefore, the experience of teachers' professional growth of primary classes as a competitive specialist is an important component of the system of continuous education of pedagogical staff and relevant at the current stage of development of Ukrainian society.

The radical education reform involves adopting new state standards, that are based on the key competencies outlined in Recommendations of the European Parliament and of the Council of Europe (EC, 2018), which should come through all subjects and necessary for the successful self-realization of an individual; introduction of a new approach "partnership pedagogy" in the system: "student – teacher – parents"; increasing the motivation of a teacher as a leader of fundamental and systemic changes by increasing wages, providing academic freedom and stimulating his/her professional growth; creation of a new school structure; decentralization of management, that will lead to partial autonomy of educational institutions; fair distribution of public funds to ensure equal access for students to quality education; rethinking the role of a teacher and a student, that is predetermined by the division of responsibility between them for learning outcomes (Elkin et al., 2017).

So, the social situation in the society poses a problem of training of pedagogical staff qualitatively in a new way, requires a scientific rethinking of values of the system, formation of professional competence of primary school teachers, actualizes the search for optimal forms of this process during the period of study at a higher educational establishment.

Today, it is common to divide competencies into two groups: subject-specific (professional) competences (depend on the subject area, determine the profile of the educational program and the qualification of a graduate) and general competences (are univer-

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sal, non-subject-related, for example, the ability to study, creativity, knowledge of foreign languages, basic information technologies).

Radical changes in the educational process are aimed at eliminating the inconsistencies between the current system and social requirements for it. The development of a renewed education system requires from a teacher the ability to effectively master new professional skills, the ability to find a way out of the most unpredictable production situations, cooperate in a team, correlate himself/herself with specific professional roles and perform them effectively.

Therefore, according to the above mentioned, the main aims of the professional competence's developing of primary school teachers are to improve the teacher's education at intellectual and general cultural levels, to develop pedagogical skills in accordance with the strategic goals of the New Ukrainian School concept as a dynamically developing system.

The purpose of the article is to cover contemporary problems of the professional competence's developing of primary school teachers of the New Ukrainian School as a competitive specialist in the aspect of foreign language teaching.

We used the following general scientific methods: analysis, systematization and generalization of scientific literature.

This problem is at the centre of current research. Thus, a number of scientists devoted their works to the improvement of the training of future primary school teachers' system (Kovshar et al., 2019; Leshchenko et al., 2020). Initial positions of person-centered learning as a key condition for the formation of professional competencies was grounded in (Bennetts, 2003; Clouston and Whitcombe, 2005; Denham et al., 2012; Derntl and Motschnig-Pitrik, 2004; Dolezal et al., 2018; Harri-Augstein and Thomas, 1979; Haselberger and Motschnig, 2016, 2011; Korhonen et al., 2014; Kyprianidou et al., 2008; McGraw et al., 2017; Miller, 2010; Motschnig-Pitrik and Standl, 2013; Motschnig-Pitrik, 2013a, 2005, 2013b; Motschnig-Pitrik and Rohlíková, 2013; Motschnig-Pitrik and Derntl, 2008; Motschnig-Pitrik et al., 2008, 2007; Motschnig-Pitrik and Figl, 2007; Peetsma and van der Veen, 2013; Rowley and Lester, 2016; Vitsenets, 2012; Xu and Woodruff, 2017).

It is stated in the New Ukrainian School Concept nowadays the problem of using internal reserves to increase the efficiency of students' learning is becoming more acute (Kirik and Danilova, 2019).

The priority problem of higher educational institutions of pedagogical orientation at the stage of Ukraine's integration into the European educational area is the preparation of teachers of a new generation: the modern school needs teachers who are capable of realizing the creative potential of a student.

According to scientists who study the theory and methodology of vocational training, the priority form of the education system's development should be the creation of integrative training courses for teachers, that reflect the dynamism of the modern scientific paradigm (Vuchic and Robb, 2006).

2 NUS REQUIREMENTS AND THE LEVEL OF TRAINING OF PRIMARY SCHOOL TEACHERS

The new school needs a teacher who works in the format of creative searches, based on the achievements of traditional methods and, at the same time, has innovative elements, a teacher who is self-motivated not for reproduction, but for an experiment, research, innovation. At the same time, such a teacher should be responsible for the results of his work – the students' education and upbringing. A modern teacher should make a scientifically and pedagogically sound choice of a curriculum, appropriate didactic means, textbooks and manuals, develop such methodical system of teaching in a subject in order to stimulate students' interest in creative search, to realize the meaningful aspect of certain subject teaching, which provides ensuring that the student's level of education corresponds to the requirements of development of science and practice's current level, that is to be professionally mobile.

At the present stage of primary education a significant role is given to the technological approach to the organization of educational activities, that is the use of Internet resources. It is due to the fact that such teaching aids promote purposeful synthesis of methods and open new opportunities in the organization of person-centered educational process.

The current growth rate of scientific information and the educational process's reform require a modern teacher to be able to lifelong learning. The beginning of the information civilization is putting forward an upgrade of the value system for the future generation: from "education for life" to "lifelong learning", that makes the issue of a competitive teacher of educational institution relevant (Verkhovna Rada of Ukraine, 2017).

The formation of primary school teachers and other professionals' competitiveness is a time-delayed process that is based on systemic, activity, competence and other approaches, which facilitates two-way communication between the education system and the labour market, therefore, first of all, the state standards for specialists' training in higher education should be practice-oriented in order to ensure competitiveness.

Higher educational institutions of Ukraine have the task of restructuring the system of pedagogical vocational training in order to develop professional and pedagogical knowledge, skills and abilities which are directed at such an organization of pedagogical interaction that would meet the principles of humanity, democratization, when both a teacher and students are active participants in the pedagogical process during the course of teaching.

An integral and important part of the formation of the New Ukrainian School in the period of development of primary education is characterized by the significant influence of computer technology, which forms a global information space aimed at the harmonious entry of younger student's personality in the information society (Bibik, 2017).

Today, Ukraine is on the path of democratic transformations and technological development in all spheres of society caused not only by the need to renew and change society but also as a result of interactions and transformations that are taking place in the world. On the way to entering the European educational space, Ukrainian education needs to bring all its components to generally accepted world standards, including computer technology. ICT, in particular distance learning tools, occupy a prominent place in the world's best educational models (Bobyliev and Vihrova, 2021; Shokaliuk et al., 2020).

The activity of a teacher as a competitive specialist requires new approaches to the professional skills' formation, development of creative abilities, and in general – improving the professional competence of specialists who carry out the educational process.

The determinative purpose of primary education should be to organize a joint search for a solution to problems, not to "convey", "explain" and "show", but to organize students' search activity at a lesson, following the principles which the organizing active forms of work's process is based on, in the context of educational reform: principle of interaction, principle of subject-subject relations, principle of activity, principle of reflection, principle of comfort, principle of combination of collective, group and individual work, principle of integration. Thus, a teacher must become an invisible conductor, be able to hear, notice, correct, support each student, and to organize students' collaboration.

In terms of the New Ukrainian School concept, a teacher (coach, tutor, facilitator) should act as the organizer of the training, who is intended to provide an individual approach to each student. The lessons should be dominated with productive, actively-creative methods that offer independent and creative activity of problematic and practical nature, which aim to give not only knowledge but also the experience of their self-acquisition.

The Professional Standard for Primary School Teachers, developed by the Ministry of Education and Science of Ukraine together with the Ministry of Social Policy of Ukraine, outlines functions, including professional competencies, knowledge, skills and abilities. Information and communication competence involves mastering the basics of digital literacy, the ability to use information technology in education. As all subjects are integrated into primary school, namely "foreign language", "technological", "ICT", they are designed to allow a teacher the opportunity to understand their strengths, knowledge, and the ability to be creative (IMZO, 2018).

That is why a primary school teacher must consciously and competently learn new achievements of pedagogical activity, the main of which is the development of the child's personality.

In the market of pedagogical services, a contemporary primary school teacher exposes his/her high professionalism in the possession of Internet resources, the ability to interact, teach, educate, in terms of new social needs. The use of Internet tools in primary school, as practice shows, changes the nervous tension of students, gives the opportunity to change their activities, switches attention to various key issues, lesson topics, in addition, develops children's personal skills such as working in a group, a team, individually, resolve conflict situations, actively listen to others, discuss their own opinions, analyze, make decisions.

According to the state documents that regulate educational reforms (NUS Concept, new State Standard, typical educational programs), a primary education teacher should be oriented in changes of teaching methods and introduction of new educational technologies in the educational process.

The development of a specialist's personality should take place in the conditions of constant transformation, which implies internal activity, which allows going beyond the established standards of personality and social necessity, to realize his/her understanding of content, the purpose of one's own activity.

Today the professional development of teachers is regarded as a continuous process, which must be carried out on the basis of known, modified or newly created, developed forms and methods of organization of professional development. It is a constant process of choosing and combining different forms, methods, technologies that are most optimal in a particular situation, in a particular place. Therefore, in the organization of training and professional development of pedagogical workers on the available technologies, forms and methods of education, which are introduced in the education system, one should choose those that are most contribute to the formation of professional competence (attitudes, values, knowledge, skills, qualities required for effective professional activity) (MON, 2017).

Important tasks of teacher's professional growth are not only knowledge and skills' mastering of a certain area that are necessary for professional activity, but also mastering the techniques of self-search information, mastering new technologies, solving previously unknown educational tasks (MON, 2017).

According to the aforementioned, the development of the teacher's professional competence causes an increase of the problem of postgraduate education, which is considered as a process in Ukraine and is aimed at the comprehensive development of an individual, the systematic updating of students' knowledge, the reorientation of psychological attitudes, the change of thinking stereotypes; the orientation of teacher's motivation for self-development, the formation of value humanistic orientations and reflective culture, the realization of new epistemological strategies of education.

The strategy for implementing a teacher's in-service training plan takes place in the current stage of educational reform in a new way. Approaches to evaluating the results of the educational process are changing, which will provide changes in the mechanisms of pedagogical staff's certification partly and will affect teacher's certification processes, which are just beginning to take form.

3 FOREIGN LANGUAGE EDUCATION IN PRIMARY SCHOOL: PROBLEMS AND WAYS TO SOLVE THEM

3.1 Experience of Foreign Countries in the Implementation of Early Foreign Language Learning

The teaching of foreign languages at preschool age and at the initial stage of school education is not only about language learning, but also about the general development of personality, which is the main goal of primary school education, as well as language and cultural preparation of children for communication in Europe and providing sustainable foreign language skills.

The problems of early foreign language learning are the subject of increased attention of scientists in most countries because early language learning is seen as a way to the declared goal in Europe – the real multilingualism of citizens. Therefore, in the system of general education, students have to learn two foreign languages in addition to their native language, which means that the studying of the first language (mostly English) begins in primary school. Germany, which has experienced several waves of migration and must accept the country's multilingualism and multiculturalism as a fact, began to introduce early foreign language learning in the 1980s, based on the research of scholars in this field. Among the German scholars who have studied the problem of early foreign language learning, it is worth mentioning first of all the works by Hohenberger and Peltzer-Karpf (Hohenberger and Peltzer-Karpf, 2009), Kopaczyk and Sauer (Kopaczyk and Sauer, 2017), Pelz (Pelz, 1978), Schmid-Schönbein and Fröhlich-Ward (Schmid-Schönbein and Fröhlich-Ward, 1983), Fröhlich-Ward (Fröhlich-Ward, 1981, 1979), Hufeisen and Jessner (Hufeisen and Jessner, 2009), Marx and Hufeisen (Marx and Hufeisen, 2004), Hufeisen (Hufeisen, 1998, 1995). Ukrainian scientists did not ignore this problem. They agree on the importance of taking into account the needs and desires of children of this age in early foreign language learning and avoiding situations that could cause fear and apprehension. Therefore, most pedagogical approaches to teaching foreign languages at an early age follow the model of children's learning of the native language through imitation mechanisms.

Due to the experience of learning the first language, children unconsciously use the learning strategies known to them, so this fact should be taken into account, as well as the fact that success in early learning depends not only on a teacher who influences students of this age group both positively and in a negative sense but also from the educational material that is offered. Therefore, the educational material and the format of its presentation should be selected that would meet the expectations of students. It should be noted that scholars and practitioners show the unity of views on determining the goals and tasks of foreign language teaching at the initial stage. In their opinion, they are the following: students enjoy contact with a foreign language; show interest in them; develop speech and hearing skills; in the process of game learning they learn certain rules and language structures; develop the ability to distinguish the melody, rhythm and intonation of another language; develop language consciousness and a sense of one's own and another language; have the opportunity to look into the world of another culture and get acquainted with the way of life of their peers – representatives of another language community; develop a tolerant attitude, openness and willingness to understand "others".

Material that is both educational and entertaining, which fully meets these requirements, is available on the YouTube platform, where you can find multilingual content on various topics, which is easy to didactic (Chorna et al., 2019). In addition, there are channels that already offer training programs for young children, taking into account their interests and inclinations.

In addition to the German experience, the positive experience of the Finnish education system in the introduction of foreign languages (not one, but several) in primary school and preschool education also deserves attention, because the Finnish model of education is the basis of the New Ukrainian School concept.

The Finnish authorities recognize the importance of learning several languages for children and promote the education of true polylingual personalities. Thus, Finnish education, satisfying the requirements of society, in addition to learning Finnish and Swedish, introduces early foreign language teaching (L3). In 2003, the National Core Curriculum for Early Childhood Education and Care outlined the position of learning a foreign language other than Finnish and Swedish and recommended the introduction of a foreign language from the age of 3, when native language skills are already sufficiently developed (www.julkari.fi, 2003), which is entirely the result of the study of Tove Skutnabb-Kangas (Skutnabb-Kangas, 1984, 1986; Skutnabb-Kangas and Toukomaa, 1987; Skutnabb-Kangas, 1996) and the scheme of threshold levels, based on the established relationships between the type of bilingualism and intellectual development (Hamaniuk, 2012, p. 273).

In December 2012, the first Government Strategy for the National Languages of Finland was adopted in order to support two national languages (Finnish and Swedish) and to comply with language legislation. The components of the strategy include: increasing the importance and awareness of national languages, the presence of both languages in planning for the future, good knowledge of languages, etc. (Tallroth, 2012).

Of particular note is the Finnish government's The Key Project for Languages project, which aims to increase and diversify language teaching, namely: integrating early language learning into Finnish education (with a much wider scope than before); providing students with a wider language repertoire; creating a friendly and encouraging attitude to learning foreign languages. The project is supported by the Finnish National Agency for Education. The aim of this project is to find innovative ways of learning and introducing languages for young children that would motivate and be to the liking of students. Moreover, the project aims to find ways to introduce foreign languages in preschools (kindergarten is compulsory for all Finnish students) for very young children aged 4 to 6 and to encourage the natural interest in learning the language, because it is at this age children are particularly sensitive and prone to language learning. In addition, young children are more open to new experiences and other people, more inquisitive and not ashamed to communicate even with limited knowledge of the language they are learning. Also, the project proposes new and innovative ways to integrate language learning in the teaching of other subjects, such as physical education, music and mathematics. In addition to integrating language learning into other subjects, language learning can also take place outside of lessons (Inha and Kähärä, 2018).

Parallel learning and multidisciplinary modular learning are used in Finnish schools. Songs, games and music can be used in the classroom for young children and preschoolers to diversify and intensify the learning process. Another feature of this learning process is the coordinated interaction of the entire educational community and cooperation with parents, by informing them about the usefulness of learning several languages, which will also encourage and induce parents to support their children in learning several languages. Among the advantages of learning foreign languages at an early stage in Finnish education are knowledge of several languages, improvement of memory, development of multitasking skills, prevention or delay of Alzheimer's disease, etc. And most importantly, by introducing early learning of foreign languages, Finnish education creates a "language path" that begins in preschool, continues to form and develop until the end of basic and secondary education, and continues throughout a person's life.

Obviously, the education system in Finland is recognized worldwide. Equality, comprehensive education, early introduction of foreign language learning are considered as value characteristics of Finnish education. By giving priority to the development of multilingual and multicultural competencies of a democratic citizen, Finnish children have the right and obligation to learn three languages: Finnish, Swedish and one foreign language, mostly English (90%). Also, in addition to English, children are encouraged to learn other foreign languages.

3.2 The Results of Foreign Language Learning in Primary School through the Prism of Legal Documents

The experience of foreign, primarily European countries in the field of foreign language education in primary school and in the context of early foreign language learning has prompted a revision of key approaches to the organization and content of foreign language learning in the domestic education system. It is possible to demonstrate changes in approaches to teaching in the New Ukrainian School and, accordingly, to consider the issue of proper training of primary school teachers at the current stage of implementation of NUS's ideas in the education system on the example of foreign language teaching.

Foreign languages have become very popular in recent years for a number of reasons. Globalization processes, mobility (Striuk et al., 2015), informatization of society (Fedorenko et al., 2019) and availability of information in foreign languages, the ability to travel due to visa-free travel regime with EU countries have highlighted the need for foreign language skills, which, accordingly, became an argument in favour of learning foreign languages primarily for parents who previously had an indifferent attitude to this subject. In addition, the practice of teaching foreign languages prompted changes to many Ukrainian regulatory documents, which regulate foreign language education, after the appearance of "The Common European Framework of Reference for Languages" (hereinafter CEFR) and the additional volume to CEFR. These are, first of all, the project "Language Education Concepts", the State Standard for Pre-school Education, The State Standard of Basic Secondary Education, where the issue of teaching foreign languages is arisen.

The State Standard for Primary Education 2020 defines the goal of foreign language education as "the formation of foreign language communicative competence for direct and indirect intercultural communication, that provides the development of other key competencies and meets the various life needs of the learner" (MON, 2017).

The text of the document states that "the learner: perceives information expressed in a foreign language in the context of direct and indirect intercultural communication, and critically evaluates such information; understands the read foreign texts of different types for information or for fun, uses the read information and critically evaluates it; provides information, expresses thoughts, feelings and attitudes, interacts with others orally, in writing and in real time, using a foreign language" (MON, 2017). The requirements are presented in table 1.

Quantitative indicators are also determined. Thus, almost a third of the total number of hours devoted to language and literature training in primary school is devoted to foreign language education. Detailed information is presented in table 2 (MON, 2017, Annex 12). Communicative (receptive and productive) skills for students in grades 1-2 and for grades 3-4 are differentiated among the compulsory learning outcomes and other things according to three criteria in annex 3: perception of information expressed in a foreign language and its critical interpretation; understanding what is read to obtain information and its critical interpretation; providing information, expression of thoughts, feelings and interaction with others (orally, in writing). Italicized skills for each of the criteria allow us to trace the dynamics of students' communication skills, but a document that declares intentions does not always guarantee the achievement of the declared level and, unfortunately, does not always reflect the real state of affairs. It is clear that for each criterion for 1-2 and 3-4 grades students communication skills are written so that there is an obvious progression in the results, however, the requirements for the level of language proficiency in primary school and the realities of both students and teachers, who teach them, indicate the existence of certain contradictions, that makes it impossible to achieve the goal. This is, firstly, the lack of hours devoted to learning a foreign language; secondly, the unwillingness of primary school teachers to use innovative teaching technologies, as most of those who work in schools are still members of the "old guard", who do not understand the need for a radical change in approaches to learning and do not always or not fully have the skills to use informative learning tools; thirdly, it is about only partial providing of technical needs in primary school by the state, as the use of innovative methods requires considerable "technical" support in the form of teaching aids (computers, multimedia boards, licensed programs, and, most importantly, stable Wi-Fi). The lack of certain conditions to provide learning outcomes, that are formulated in the State Standard, can be partially compensated by the technical capabilities available in each family (the presence of a computer, a laptop or a smartphone, as well as the Internet) in combination with a well-thought-out organization of independent work, wide offer of on-line resources.

Table 1: Requirements for compulsory learning outcomes of learners' training in language and literature education (foreign language education) (MON, 2017, Annex 3).

General learning outcomes of learners	**Required learning outcomes of learners**	
	1-2 grades	**3-4 grades**
Perception of information expressed in a foreign language in the context of direct and indirect intercultural communication, and critical evaluation of information		
Perceives oral information	*understands* short, simple questions, statements, requests/instructions and responds to them verbally and/or nonverbally	*identifies* in the oral message information on various tasks on familiar everyday topics
Critically evaluates oral information	*recognizes* familiar words and phrases during the perception of oral information	*understands* the meaning of oral expression in a familiar everyday context
Understanding of read foreign texts of different types to obtain information or for fun, use the read information and its critical evaluation		
Perceives the text	*recognizes* familiar words based on evidence	*recognizes* familiar names, words and elementary phrases in short, simple texts
Analyzes the read information		*defines in the text information* on various tasks on familiar everyday topics
Providing information, expressing thoughts, feelings and attitudes, interacting with others orally, in writing and in real time using a foreign language		
Performs oral interaction	*asks and reports* information about himself and everyday activities, using short word combinations and using gestures if necessary	*communicates* on familiar topics, responds to simple statements about meeting urgent needs and expresses such needs
Orally expresses his/her own thoughts, feelings, attitudes and positions	*describes himself/herself* and *his condition* in short phrases	*tells about* people, the world around and life in simple, separate phrases and *expresses his/ her attitude*
Makes written interaction	*provides the simplest information* about *himself/herself* in writing (note, questionnaire)	*requests and provides personal information* in writing using simple words, short sentences and word combinations
Expresses his/her thoughts, feelings, attitudes and positions in writing	*writes short* phrases about himself/herself	*provides in writing information* about himself/herself, the world around, life, using simple words and expressions
Interacts in real time	*writes short phrases* in real time using a dictionary if necessary	*creates* real-time *simple messages* with a few short sentences

Table 2: The primary school curriculum.

Title of the educational field	**Quantity of hours per year**				
	1st grade	**2nd grade**	**3rd grade**	**4th grade**	**total**
Invariant component					
Language and literature, including:	315	350	350	350	1365
Ukrainian language and literature	245	245	245	245	
foreign language education	70	105	105	105	

4 INTERNET RESOURCES AS A MEANS OF PROVIDING THE RESULTS OF FOREIGN LANGUAGE LEARNING IN PRIMARY SCHOOL

We researched and analyzed online tools for learning English by younger students. Table 5 provides a general description of online tools that are available and most in-demand in Ukraine.

Thus, online courses, online schools, online games, online services, online platforms should be singled out among the online resources for learning English by younger students. Some are free, but most of them require registration and are paid for. These online resources are designed to learn one (English) language or three and more languages, some have a mobile application. Outlined online tools for learning foreign languages by younger students can be both individual and group. Online schools give an opportunity to track learning outcomes, to control, to communicate with native speakers, to get a certificate.

Learning foreign languages in primary school is “the formation of students’ communicative competence, which is provided by linguistic, speaking and socio-cultural experience, that are agreed with the age capabilities of primary school children” (MON, 2019b). Teaching students foreign languages requires the development of communicative activities, that are divided into productive (speaking, writing) and receptive (listening, reading). The following classification (table 3) gives an opportunity to find out the presence or absence of listening, reading, writing and speaking skills in the analyzed media content, as these skills are the psycholinguistic basis of communicative foreign language competence and are needed for further improvement.

The Common European Framework of Reference for Languages identifies three basic components of communicative competence: linguistic, sociolinguistic, pragmatic (Council of Europe, 2001). The development of linguistic competence of primary school students needs special attention, because the motivation to learn foreign languages is formed, the language system is mastered and the basis of knowledge, skills, practical skills is laid at the initial stage of learning foreign languages, also psychological preconditions are created for the formation of personality and further study of foreign languages. In the following classification (table 4) we have identified the components of linguistic competence, namely: lexical, grammatical, semantic, phonological, orthographic, orthoepic competences, as the formation of these competencies is the basis for the development and implementation of all other competencies and competences.

According to the Common European Framework of Reference for Languages, sociolinguistic competence has the following components: linguistic markers of social relations, politeness conventions, expressions of folk-wisdom, register differences, dialect and accent (Council of Europe, 2001). Analyzing Internet technologies for learning foreign languages by younger students, we singled out sociolinguistic competence as a general component, taking into account the development of knowledge and skills that are required, namely: politeness rules, use and choice of greetings, address forms, conventions for turntaking, use and choice of expletives, expressions of folk-wisdom. The considered Internet technologies do not provide the development of the ability to recognize linguistic markers of social structures, dialect and accent, for example: social class, regional provenance, national origin, ethnicity, occupational group, etc. and have a relatively neutral register of language acquisition.

The pragmatic competence is also absent in the suggested classification (table 4), as the development of discourse, functional and design competences is absent or insignificant in the proposed Internet resources.

The proposed classification clearly shows the presence or absence of the development of certain communicative speech competence in the studied Internet tools for learning English by younger students.

5 REQUIREMENTS FOR PROFESSIONAL COMPETENCE OF PRIMARY SCHOOL TEACHERS AND WAYS TO IMPROVE IT

With the formation of the New Ukrainian School, the requirements for the professional competence of teachers have significantly increased, as the loss of the ability to regulate the pedagogical process leads to the inhibition of the harmonious development of interaction with students. The need for professional self-development of a teacher involves the creation of conditions for the implementation of his/her own educational trajectory. The primary task of postgraduate education as an organic part of continuing pedagogical education should be to stimulate self-education and professional competence of teachers (Council of Europe, 2001).

We understand the professional competence of a primary school teacher to implement the tasks of the concept of the New Ukrainian School as the ability of a specialist to apply theoretical knowledge in planned and unforeseen pedagogical situations (IMZO, 2018).

Society’s need for competent primary school teachers with an arsenal of information technology (able to receive, process and use information with the help of computers, telecommunications and other means of communication) is becoming a leading factor in modern educational policy.

The mobility of a primary school teacher and his/her lifelong learning should help in changing the educational area and in the creation of a school that combines theoretical and practical knowledge of skills namely.

The practice of educational process’s realization in the conditions of modern primary school proves that a successful teacher must master not only the the-

Table 3: Classification according to the development of skills.

No.	Title	Development of listening skills	Development of reading skills	Development of writing skills	Development of speaking skills	Additional features
1	Study-languages-online.com	+	+		+	Memory development
2	cambridgeclub	+	+	+		Disclosure of a child's talent
3	Lingualeo	+	+		+	
4	Iqsha	+	+			
5	Duolingo	+	+	+	+	Development of logic
6	Cambly	+	+	+	+	
7	Englishdom	+			+	
8	Learnenglishkids.british-council.org	+	+	+	+	
9	Interneturok	+	+	+		
10	Puzzle-English	+	+	+	+	
11	Busuu	+	+	+	+	
12	Poliglotiki	+	+		+	Development of memory, attention
13	Memrise	+			+	
14	Starfall	+	+			Emphasis on research, play and positive reinforcement
15	Simpler	+	+		+	
16	Cambridge English				+	
17	Games to learn English	+	+		+	Entertainment
18	Teremoc		+			Memory development
19	Novakids	+	+	+ (in the presence of a special pen-Novakid)	+	Development of attention
20	Skyeng	+	+	+	+	
21	EnglishDom	+	+	+	+	Result control
22	Preply	+	+	+	+	
23	English show	+	+	+	+	
24	Doma.uchi	+	+		+	

"+" – the development of the specified competence is available.
" " – the development of this competence is absent or insignificant.

ory and techniques of students' personality development, a specific analytical and diagnostic culture, but also be able to predict students' achievements, both educational and personal.

Today, more than ever, the effectiveness of teachers' work depends on the level of professional training and other components of pedagogical professionalism. Diagnosis, prediction, development of author's programs, optimization of all aspects of the educational process are becoming the norm of pedagogical activity in educational institutions of Ukraine.

The new society is forcing a teacher to be a creative, competitive, self-affirming personality. The future of our country depends on how much a teacher will be ready for such challenges because education in the age of high technology is a factor of stabilization, effective economic development and prosperity of a country, its competitiveness and national security.

The modern professional activity of a primary school teacher is based on his/her results of pedagogical activity as a highly professional specialist, who is acquainted with the modern world requirements for the educational process of the primary level of education; prepared for the organization of educational ac-

Table 4: Classification according to the development of communicative speech competence.

No.	Title	Lexical	Grammatical	Semantic	Phonological	Orthographic	Orthoepic	Socio-linguistic
1	Study-languages-onlinecom	+	+		+	+	+	+
2	cambridgeclub	+	+	+	+	+	+	+
3	Lingualeo	+	+	+	+		+	+
4	Iqsha	+	+	+		+		+
5	Duolingo	+	+	+	+	+	+	+
6	Cambly	+	+	+	+	+	+	+
7	Englishdom	+		+	+	+		+
8	Learnenglishkids.british-council.org	+	+	+	+	+	+	+
9	Interneturok	+	+	+	+	+	+	+
10	Puzzle-English	+	+	+	+	+	+	+
11	Busuu	+	+	+	+	+	+	+
12	Poliglotiki	+	+	+	+	+		+
13	Memrise	+		+	+			+
14	Starfall	+		+	+			+
15	Simpler	+	+		+			
16	Cambridge English	+		+				
17	Games to learn English	+	+	+	+	+		+
18	Teremoc	+		+		+		
19	Novakids	+	+	+	+	+	+	+
20	Skyeng	+	+	+	+	+	+	+
21	EnglishDom	+	+		+	+	+	+
22	Preply	+	+	+	+	+	+	+
23	English show	+	+	+	+	+	+	+
24	Doma.uchi	+		+	+			+

"+" – the development of the specified competence is available.
" " – the development of this competence is absent or insignificant.

tivities of younger students as a pedagogical (partnership) interaction, that is aimed at the development of each individual and individual's preparation for solving life-giving tasks.

Today, the professional competence of primary school teachers – is the ability to pedagogical activity, the organization of educational process in primary school at the level of modern requirements; the ability to work efficiently, solve standard and problematic professional tasks effectively that arise in the process of education, upbringing and development of primary school students. The basis of this ability is the unity of theoretical and practical of a teacher's readiness to do the pedagogical activity, which is come out in the presence of knowledge, skills, values of attitudes to professional activity's system (Verkhovna Rada of Ukraine, 2017).

Savchenko (Savchenko, 2015) considers that content and fundamentality are the core of professional competence, which should provide advanced training of a specialist. The academician concludes that it is necessary to update the content of methodological training of teachers according to the principle of integrity, systematic and integration; taking into account those processes that determine the activities of modern primary schools. In addition, it should be taken into account the need for the changes that have taken place in society and are related to scientific and technological progress, enhanced integration processes, informatization and computerization.

According to the State Standard of Primary Education and the New Ukrainian School Concept, the components of the professional-pedagogical competence of primary school teachers are:

- professional knowledge;
- professional art and skills that are necessary for successful completion of job responsibilities;

- business and personal qualities that contribute to the fulfilment of his/her own strengths, abilities and capabilities in the process of fulfilling their functional and official responsibilities;
- general culture that is necessary for the formation of a humanistic outlook, the definition of spiritual values, moral and ethical principles of personality;
- motivation for professional activity (MON, 2017).

The psycho-pedagogical competence of a teacher in the aspect of the New Ukrainian School concept should include awareness of the individual characteristics of each student, his/her abilities, strengths of will and character; awareness of "the parent-student" communication processes; knowledge of how communication processes contribute to or hinder the achievement of the desired pedagogical results; realization of own optimal choice of teaching methods, search for possible ways of self-improvement.

The professional growth of a teacher as a competitive specialist should be aimed at implementation of the New Ukrainian School's conceptual principles and focused on the development of two major innovations – the competence paradigm of education and pedagogy of partnership.

The educational reform implementation plan provides continuity of realization of its conceptual provisions (1-4 grades), taking into account the appropriate (distance) resource software at each stage of teaching a younger student (online learning platforms, online textbooks, multimedia boards, media technologies), which requires a teacher to improve his or her skills in the system of continuing education and in the context of social change (MON, 2019a).

This is due to the presence of primary level teachers' stereotypes of thinking that negatively affect the development of younger students; uncertain readiness to innovate, problematic use of active teaching methods, game technologies.

The professional growth of a modern teacher's personality is directly related to the need for modernization of school, scientific, methodological and research work and its improvement.

As a rule, the methods and forms of traditional educational activities are reduced to unilateral influence of a teacher, the role of which is a clear presentation of information. As practice shows, the information-reproductive teaching methods of a descriptive nature are dominated in general education institutions. Problematic and practical methods are mostly used for illustration and clarity, the reproduction of past experience predominates. Individually-collective forms of the organization of training are usually used, according to which the material is assimilated individually, but at the same pace for the whole group (Bibik, 2017).

Improving the effectiveness of English lessons in primary school, by strengthening the informational, communicative and emotional saturation of the educational process, is an urgent need of leading modern methodists (Flynn, 2007; Goh and Fang, 2017; Hashim and Yusoff, 2020; Järvinen and Twyford, 2000; Niyazova and Muratova, 2017; Pokorna, 2015; Reid, 2013; Xu et al., 2019).

The task of a primary school teacher is to make a proper English lesson's plan in order to prevent a decline in children's interest in such types of work that involve student's mobility, such as online games, staging songs and stories, colloquialisms, riddles, fairy tales. Their purpose is to relieve emotional tension during distance learning, to rest eyes, to relax different muscle groups. According to didactics in primary school, it is recommended to take dynamic breaks during classes. Their organization gives students a real opportunity to move, relieve intellectual, physical fatigue, during which children invisibly name and repeat the typical movements of animals, performing poems, speeches, counters in foreign languages.

The current changes in society have a decisive influence on the structure and content of pedagogical education, they orient teachers of higher educational institutions to enhance their mobility by differentiating requirements to the level of education. The rapid changes in society and technological advances are so high that it becomes very difficult to train a specialist who, after graduating, would be able to work in the chosen area of activity without continuing self-improvement, continuous general and professional development.

The focus on the humanization of education in the teaching of foreign languages is present in the orientation of the learning process on the development of the personality of the younger student. Internet tools that stimulate children's creativity and create real conditions for students to achieve practical results play an important role in the development of students' speaking skills.

Technological actions in language learning are a set of actions from determining the purpose of language personality formation, preliminary design of a language learning model to the implementation of tasks in practice. The use of Internet resources in the system of language education is the educational systems that meet the latest advances in didactics, linguistics, theory and practice of language learning.

The need to use Internet tools in language learning is due to the contradictions between the lack of opportunities in the traditional education system and modern social needs. The objective need for the use of Internet tools in the study of languages is the strengthening of the communicative aspect in the formation of language personality and the intensive development of information technology. The use of Internet tools has broad prospects for use in foreign language learning, as they easily combine a number of technologies: game, interactive, project, technology for the development of critical thinking, technology for the development of critical thinking, early and intensive learning technologies (Pokorna, 2015).

The use of Internet tools in primary school has its own specifics: it is necessary to take into account the age, individual and psychological characteristics of primary school children. All parts of working with Internet tools require careful monitoring by a teacher, as both theoretical and practical knowledge and skills of younger students are still small. Working with the use of elements of distance learning requires a clear formation of aims, tasks and algorithm of actions: finding information for systematization, generalization, adaptation in future use.

Therefore, special attention in the new paradigm of education in general, and continuing education of primary school teachers, in particular, should be paid to the technologization of the content of the learning process. Such education will become the means of information-modernized perception of the world by a younger student.

Postgraduate education centers are designed to regulate the needs of teachers in their professional growth. Every year there is an opportunity to undergo advanced training (within 50 hours) in order to acquire skills and abilities of free orientation in information flows, the use of various online learning platforms.

The leading direction of the postgraduate educational centers' work (according to the New Ukrainian School Concept) is the unified mechanism of reorientation of training's creation in relation to the updated content, forms and methods of teaching. The creative use of traditional methods and forms, together with the introduction of innovative mechanisms, should facilitate the development of modern approaches in the formation of teacher's professionalism throughout life.

The effectiveness of teachers' further continuing education will depend not only on basic professional training but also on the implementation of daily practical training tasks, improvement of professional skill, level of research work, individual characteristics and actual teacher's needs.

Continuing education should be aimed at developing cognitive skills, the ability to create an individual plan for professional self-development (to construct personal knowledge) independently, the ability to navigate the information space, to generalize and integrate new information from various sources in the process of theoretical and practical learning, the ability to improve yourself constantly.

Modernization of the system of pedagogical staff's professional development, improvement and modernization of postgraduate pedagogical education, as a whole, is one of the most urgent tasks facing the educational sector in Ukraine today. A powerful tool that can increase efficiency and accelerate the pace of its implementation is the monitoring of modernization processes in the sphere of postgraduate education, as well as conducting relevant sociological researches. Such scientific intelligence will allow to branch leadership, individual institutions and other institutions to obtain information about the course of development of postgraduate pedagogical educational system systematically, that is necessary for making management decisions on its improvement, timely elimination of shortcomings, as well as to provide feedback to direct consumers of educational services, identify their real needs, expectations, and attitudes.

The system of in-service training of primary school teachers in the context of education reform promotes the intensification of educational process, improvement of its efficiency and quality of results; the systematic integration of subject tasks, development of experimental research skills; the building of an open education system that provides each participant with his/her own trajectory of self-education; the formation of teachers' information culture.

The conditions for teachers' professional development during in-service training under the conditions of the NUS Concept are:

- diagnostics of professional competence of educators;
- providing a differentiated approach to the pedagogical staff's in-service training;
- introduction of innovative training technologies;
- updating the content of educational and professional programs;
- introduction of information and communication technologies in the educational process;
- providing practical orientation of in-service training courses;
- feedback organization (Elkin et al., 2017).

The main areas of solving the implementation of training courses according to the concept "online", with different versions of programs that provide the opportunity to study and improve new information technologies, information culture as part of professional competence, the use of multimedia technologies that facilitate learning and memorization of learning material, because their use individualizes the learning process. Programs of advanced training courses for primary school teachers in (Kryvyi Rih State Pedagogical University) are designed for the needs of teachers of different categories in accordance with the teaching experience and meet the requirements of a teacher in his/her acquaintance with the potential of modern technologies, ability to use them in practice. A student of a group of primary school teachers takes a set of tests to check the level of professional competence at the final stage, this allows mobile, impartial and objective modular control (60 / 30 hours programs).

6 CONCLUSIONS AND PERSPECTIVES FOR FURTHER STUDIES

It is dictated by the needs of today, that the high level of education requirements for primary students can only be realized if a primary school teacher is a highly professional, competent specialist.

Such an educator should have both basic educational training in mastering professional knowledge and skills that correspond to the level of modern psychological and pedagogical sciences, and be aware of the purpose and tasks of professional work in a coherent system of continuous education, be modernly mobile, respond quickly to changes in the social situation of younger students' development; strive for self-improvement, self-realization and civic activity in the conditions of the New Ukrainian School.

The efforts of all educators today should be aimed at improving the quality of online education. The key issue to improve this quality is the introduction of effective changes in educational institutions, which can be implemented only by a competent teacher who is ready to improve and work on their own professional development constantly.

Thus, learning according to the needs of modern society is impossible to imagine without a distance form of learning. Distance learning focuses on the best world methodological experience using the most modern and highly effective pedagogical technologies. Such training provides opportunities for use in the educational process: flexibility, modularity, parallelism, a significant amount of educational information, economy, manufacturability, social equality. Acquisition of professional competence of primary school teachers in the method of organizing distance learning is a priority of advanced training courses for teachers.

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APPENDIX

Table 5: General characteristics of online resources for learning English by younger students.

No.	Title	Age	Category	Content	Advantages	Peculiarities
1	Study-languages-online.com	4-7	Online course	Each lesson is dedicated to a specific topic and consists of five or more stages. Exercises, dictionary, phrasebook, theoretical material, comments, games, the ability to check the results of exercises/tasks are available.	There is a free mobile application that does not require registration and available at any time.	Russian-language resource, learning English only.
2	cambridge-club	4-12	Online course	Classes include theoretical part; practical part; interactive activities for children in English. The received material is fixed by means of games, songs and practical exercises. Children receive certificates of achievement at the end of the course.	Children can study both in groups and individually, lessons are taught by a native speaker. Each English lesson for children online is stored in the parents' personal account.	Courses are paid for, learning English only.
3	Lingualeo	4-...	Online service	The effective service for language practice, game techniques, training on current videos, texts and podcasts from the Internet. Training in grammar, listening, reading, speaking and vocabulary are available.	Free, available 24/7 from any gadget, there is a Ukrainian-language version.	Registration is required, additional courses are paid for, English and 19 other languages are offered.
4	Iqsha	3-12	Online service	English lessons in the form of games for independent learning. Easy, interesting thematic online lessons.	Free 10 lessons a day, it is possible to practice without internet access, using a mobile application, parental control.	Registration is required, you need to pay for further classes and to achieve the best results, Russian-language service, learning English only.
5	Duolingo	5-...	Online service	The interactive service for learning English, both an educational game and an individual motivator. The site offers to understand your level of language and as a result of the test will offer an individual training plan. All training material is divided into 88 different topics, to master each of them you need to reach 5 levels, each of which involves 3-6 short lessons.	Free options are available, no ads. There is a mobile application, there is an opportunity to study offline. The first 7 days you can try the upgraded version for free.	Registration is required, Duolingo Plus version for $ 6.99 per month, learning 4 foreign languages.

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No.	Title	Age	Category	Content	Advantages	Peculiarities
6	Cambly	4-15	Online service	There is an individual schedule of classes. Each lesson is recorded, and there is an opportunity to watch videos in the personal account any time. In the chat you can write in your native language and receive automatic translation. After 10 hours of private lessons it is possible to get a certificate.	The project provides students with teachers with a British and American accent.	Registration is required, education is paid for, recommended for those who speak a little English, learning English only.
7	English-dom	8-9	Online service	Provides replenishment of vocabulary. An additional learning tool is relevant for children who are already able to perceive information independently. Hovering the cursor over a phrase, word or image, a student sees the correct spelling of the corresponding lexical unit on the monitor and listens to its pronunciation.	Free online simulator.	Registration is required, learning English only.
8	Learn-english-kids.british-council.org	5-...	Online program	The program is represented by the British Council, world experts in the field of English language teaching. There are many online games, songs, stories and activities, online courses.	Free, registration is not required.	The platform is only in English, there is a page for parents.
9	Internet-urok	7-...	Online service	It is designed to help students better to learn better. Offered online English lessons are most relevant to school curricula. There are simulators, tests and questions on knowledge of the passed material.	The topics are supported by video lessons conducted by the best teachers.	Registration is desirable, Russian-language resource, learning English only.
10	Puzzle-English	5-...	Online platform	Independent game training. After each lesson there is a test to check studied material there is an exam , at the end of the topic (10-15 lessons). It is possible to track progress. About 12,000 exercises and simulators are offered and new ones are constantly added.	There is a mobile application and a YouTube channel. There is a plan of perpetual access to all services "Puzzle-English" – you pay once and you use it all your life.	Registration is required, education is paid for, learning English only.
11	Busuu	5-...	Online platform	Profile service for learning English. The site offers partial and full courses. The site has a large number of articles with answers to questions and recommendations.	There is a convenient mobile application.	Registration is required, education is paid for, all material is in Russian, 12 languages are offered for studying.

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No.	Title	Age	Category	Content	Advantages	Peculiarities
12	Poliglotiki	1-12	Online platform	It has two directions: 1) HomeTeacher – the first video lessons of each course in recording are available free of charge; 2) OnlineTeacher – online classes in mini-groups / individually. The communicative approach to language learning.	Free test-simulators, flashcards and textbook pages in a convenient PDF format for demo lessons. There is a YouTube channel.	The platform is Russian-language and opens through VPN, English, German, Spanish, French languages.
13	Memrise	5-...	Online platform	Fun educational videos with native speakers give the necessary theory, online games and exercises allow you to practice. It is enough to spend up to 15 minutes a day in such interactive classes to improve your English.	There is a mobile application. The initial course of 90 lessons (20 minutes each) is free.	Registration is required, The first 3,000 words for free, then – $ 30 per year, it is possible to learn English and 9 other foreign languages.
14	Starfall	4-8	Online platform	There are four sections on the site. 1) ABCs – the alphabet is studied through videos and songs; 2) Learn to read, 15 lessons are offered, where the combination of letters takes place; 3) It's fun to read – learning to read in an entertaining manner, with the help of patter and riddles; 4) I'm reading – a list of fascinating stories for children to read.	Free, clicking on the word in the text, a child hears its pronunciation in a voice of a character.	The menu is only in English, registration is desirable. It is widely used in schools that teach children with special needs and learning difficulties, only English language.
15	Simpler	4-...	Online platform	The application offers to take a test to determine the level of English, and then calculates the complexity of the exercises. Grammar is presented here in the form of visual rules, and new vocabulary is presented through associations.	Learning a language in the form of a game.	There is a mobile application only. Fascinating detective stories, which are used to consoledate knowledge for a fee, learning English only.
16	Cambridge English	6-10	Online games	Cambridge's educational online games help to develop language skills and vocabulary. Focused on children who are tired of boring lessons at school.	Free, interesting and colorful, simple and fun tasks in games.	Registration is required, learning English only.
17	Games to learn English	5-...	Online games	Games of different levels of difficulty, but their task is the same – to help to learn words and to understand grammar.	Free, no registration required.	The platform is in English only.

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No.	Title	Age	Category	Content	Advantages	Peculiarities
18	Teremoc	2-12	Online games	A selection of browser games. Game training in the company of funny characters. Some of the games are based on fairy tales (Little Red Riding Hood, Miracle-Yudo). Participating in simple quizzes, children memorize the sound of letters and their spelling, learn arithmetic, get acquainted with birds, animals, names of body parts.	Free.	Russian-language resource, learning English only.
19	Novakids	4-12	Online school	Online lessons in the form of games with native speakers according to programs that meet European CEFR standards.	The first lesson is free, there is a mobile application, classes are provided by native speakers.	Registration is required, paid tuition, real-time classes, online school is Russian, learning English only.
20	Skyeng	3-…	Online school	Online classes are with teachers, interactive materials and exercises are always available online, automatic check of completed tasks.	The first lesson is free, there is a mobile application, there is an opportunity to transfer or cancel your lesson for free. After the full course (60 lessons) there is an opportunity to pass an exam and get a certificate that corresponds to a certain level of English.	Registration is required, paid tuition, real-time classes, online school is Russian, learning English only.
21	EnglishDom	5-…	Online school	50-minute online lessons with Russian-speaking teachers or native speakers, digital textbook is available.	First three lessons are free, there is a mobile application, there is an opportunity to get a certificate after completing the full course.	Registration is required, paid tuition, real-time classes, online school is Russian, from UAH 250 per lesson, learning English only.
22	Preply	5-…	Online school	There are professional tutors from 185 countries, the opportunity to choose your teacher is based on personal interests and preferences, financial capabilities and even the country. The schedule is free and adjustable in the personal account. All trainings take place in the format of live communication.	An individual study plan is discussed with a teacher at the first lesson. In case of dissatisfaction with the classes, the service will replace a tutor free of charge or refund the money spent.	Registration is required, paid tuition, real-time classes, it is proposed to study 13 languages.

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No.	Title	Age	Category	Content	Advantages	Peculiarities
23	English show	5-17	Online school	The site offers several course options. The full course consists of a minimum of 30 lessons. Each lesson lasts 45-60 minutes. There is an opportunity to track the dynamics of knowledge in the personal account. Studying is according to the program of Oxford University, as well as an application for daily practice with foreigners.	"English show" has one of the best YouTube channel that contains many useful materials.	Registration is required, paid tuition, real-time classes, online school is Russian, learning English only.
24	Doma.uchi	6-14	Online school	Individual 30-minute classes with a teacher. You can choose the frequency, pace and place of classes yourself. Emphasis is made on vocabulary and listening.	The first lesson is free.	It is Russian-language resource, from 720 per lesson, learning English only.

The Use of Software and Hardware Arduino for the Students' Formation of Research and Engineering Competencies

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Keywords: Student, LEGO, Arduino, Engineering, Physics, Laboratory Work, Research Activity, Accelerated Motion.

Abstract: The article shows the experience of using the Arduino hardware and software complex in order to develop research competencies of secondary school and high school students. Here are some examples of research projects that allow children to demonstrate their engineering skills and encourage them to further study subjects such as physics and computer science. The possibilities of Arduino to improve ready-made projects and develop their own engineering ideas are outlined. Particular attention is paid to the development of measuring devices and installations for school physical experiment, in particular devices for the study of uniformly accelerated motion. The results of research received by students during the experiment are shown. The results of students' research activities and their devices can be reproduced by other teachers and students for use during the teaching of physics in a specialized school, especially during a school experiment.

1 INTRODUCTION

The development of computer technology has greatly accelerated the exchange of information in any field of human activity. In education, the use of personal computers allows not only to increase the amount of information that the teacher passes on to his students, but also to create his own methodological developments, which allow to improve the assimilation of the obtained information by adapting it to age characteristics, social views, intellectual abilities and more (Vlasenko et al., 2021, 2020b). Also, continuous software upgrades allow teachers to create software products that previously required special engineering education to develop. But the needs of today have already gone beyond the acceleration of information processes. Now not only the speed of information processes but also their automation is important. Automated devices are increasingly appearing in our lives, so modern education should keep up with the needs of society.

Along with technological advances, the methods of student research change (Babkin et al., 2021). Involving children in advanced study of physical processes, it is difficult to limit only to the study of Physics, researchers must have some knowledge of Computer Science or engineering. The article shows the personal experience of the combination of Physics, Computer Science, Engineering and elements of robotics in the study of physical processes by students of Kryvyi Rih Science Lyceum of the Kryvyi Rih City Council in Dnipropetrovsk oblast.

The study of robots and robotics is already very popular (De La Cruz Vaca et al., 2020; Goncharenko et al., 2019; Hrybiuk et al., 2020; Valko and Osadchyi, 2021). The simplest and most understandable tool for researching and creating robots is LEGO kits. They do not require special knowledge of programming and understanding of the processes occurring in the devices that provide the models. It is enough to have a computer, a designer and a wealth of imagination. But the high price limits access to robot modeling by LEGO. The average student is able to model on such equipment only within the limits of classes and cannot afford to make his own model and leave it to himself. More affordable by price is the Arduino hardware and software package. This software package allows the student to show their creativity to a greater extent, but at the same time, and requires a deeper knowledge of

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Zadorozhnii, V. and Valko, N.
The Use of Software and Hardware Arduino for the Students' Formation of Research and Engineering Competencies.
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programming and radio engineering.

The purpose of the article is to show the possibilities of applying elements of robotics in the project activity of high school students and to use the results of their work in physics lessons. To combine robotics with physical research, the Arduino hardware and software system was chosen as a research tool. This complex was developed by Massimo Banzi in 2005 as a tool for students at the Interaction Design Institute Ivrea in Ivrea, Italy, aiming to provide a low-cost and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators (John, 2020). The name Arduino comes from a bar in Ivrea, Italy, where some of the Arduino founders used to meet. The bar was named after Arduin of Ivrea, who was the margrave of the March of Ivrea and King of Italy from 1002 to 1014 (Kushner, 2011). The main purpose of the development of the complex is to teach students how to design electronic devices, but then the capabilities of this complex went far beyond conventional engineering.

2 ANALYSIS OF PREVIOUS STUDIES

The use of Arduino has been repeatedly addressed by other educators. Andreev and Kulinich (Andreev and Kulinich, 2017) examines the problem of using information tools in the educational and research activities of students. The educational possibilities of the Arduino hardware and software complex in the context of preparing future physics teachers to organize students' innovative activities are highlighted, in particular, examples are given of its use for setting and solving physical problems, as well as for students to create their own innovative products. The authors suggest using Arduino boards to measure temperature, light and humidity at different points in the room. As well as obtaining the dependence of the photoresistor resistance to light and the resistance of the thermostat to temperature. Some examples of experimentation covering various topics (light and electrical phenomena, molecular physics) are given in their work. Somenko and Somenko (Somenko and Somenko, 2016) analyze the advantages of using the Arduino hardware and computing platform to create training physical equipment using electronic computing equipment. There are advantages of the complex, such as: convenient open source software for processing research results, availability of component parts for the manufacture of equipment, the ability to change the software and component measurement equipment independently. The example of an experiment for the study of convection in a liquid is given.

Martyniuk (Martyniuk, 2014) considers actual problems of development of methodological bases of using microelectronic circuitry in the system of professional training of students-physicists. He describes the possibilities of using the Arduino platform in the research of physics and in the design and manufacture of new training equipment. He recommends the use of such equipment for measuring humidity, temperature, light, speed, distance, etc. He recommends using different sensors to measure the same magnitude for accurate results and uses third-party software to process experiment data. Petry et al. (Petry et al., 2016) offer "Extracurricular project training in physics: integrating Arduino into the laboratory" with the help of the Arduino platform, carry out experiments in physics from optics and thermodynamics. In total, there are 11 laboratory works offered for elective classes (Petry et al., 2016). Among the proposed works are: refraction and reflection, spherical lens, sensitive and latent heat, thermal expansion in solids and liquids, photoelectric energy. The authors provide examples of experiments conducted by high school students.

Huang (Huang, 2015) has developed a series of experiments, activities and lab work to study, measure, and analyze physics phenomena in the classroom using low-cost microcontrollers and open source electronics. Based on his own research, he has proposed a number of activities that demonstrate scientific research using inexpensive and easily accessible electronics and equipment. Huang (Huang, 2015) describes two experiments. The first, in mechanics, uses a self-made device, called the "rotation". The second, on the topic of "Thermal phenomena", uses a semiconductor temperature sensor.

3 METHODS AND TECHNIQUES

For the development of engineering skills it is advisable to use the methods of project-based learning technology (Balyk et al., 2021; Glazunova et al., 2021; Gryshchenko et al., 2021; Horbatiuk et al., 2020; Iatsyshyn et al., 2020; Pavlenko and Pavlenko, 2021; Shuhailo and Derkach, 2021; Valko et al., 2020; Vlasenko et al., 2020a), which is based on the development of cognitive skills and abilities of students; ability to navigate in the information space; ability to independently construct theoretical or real models; ability to integrate their knowledge from different fields of science; ability to think critically. Project methods are focused on independent activity of students (individual, pair, group) in the time allotted for it (from several minutes to months). The sequence of research can be shown in the form of the following series: problem definition – hypothesis – problem solving – discussion of research methods – registration of final results – analysis of the obtained data – summarizing – correction – conclusions. The main thing in the interaction between teacher and student is the independence of the student, the teacher should only adjust the activities of the researcher without imposing his own ideas and decisions.

Arduino applications are written in C or C++ programming language (Arduino, 2021). The Arduino concept does not include body or mounting parts. The developer chooses the method of installation and mechanical protection of processor boards and expansion components independently. Other manufacturers offer a large number of various sensors and actuators that are compatible with Arduino processor boards. These manufacturers also produce sets of electromechanical elements that work in conjunction with Arduino boards, and develop special libraries (programs) that link the work of hardware and software. Arduino IDE software allows students to develop algorithms (firmware, sketches) for microprocessors and sensors. Working with the complex, students are able to see the principles of communication between the software and the devices for which it is designed. Creativity of students is always associated with the application of ideas. When creating robots or automated devices, students are involved in the processes that take place in the technical devices. Applied research, design, construction, development of manufacturing technologies are a list of activities that a child is involved in during the process of creating a new or reproducing an existing device. Children work with microprocessors and other radio electronics make housings and parts for devices, design and plan work for moving parts. Thus, it can be seen that using Arduino enables them to become true engineers, show their creativity and gain experience in electrical engineering.

Working with the complex, researchers are constantly dealing with electric current. It should be noted that the maximum voltage used to power the Arduino boards does not exceed 12 V, which is quite safe. And the constant connection and disconnection of sensors, the use of resistors, LEDs, etc., allows students to understand the laws of direct current, serial and parallel connection of conductors. Development of connection schemes can be carried out in two stages. The first step is to do a theoretical development with the online service Tinkercad (Autodesk, Inc., 2021), which has almost all sensors connected to the Arduino UNO board. Develop and test connection scheme. And then, in the second stage, work with real devices. This can prevent damage to the parts or board.

The end result of the above student research is the creation of an automated or controlled device. One of the ways to improve the quality of physics study is to involve children in the manufacture of measuring devices, which can then be used in laboratory physics. Microprocessor data processing enables more accurate measurements of physical quantities. Arduino sensors allow you to measure atmospheric and mechanical pressure, temperature, humidity, time, distance, resistance, voltage, current, light, etc., and the combination of several sensors with a program written in the Arduino IDE allows you to determine the value of other physical quantities, such as average speed of movement.

4 EXAMPLES OF USING READY-MADE PROJECTS WITH ARDUINO

A simple project that students can be involved in is assembling a D2-1 work robot and making a track for the movement of such a device. Robot D2-1 (figure 1) performs only one task – moving along the black line in one direction. At first glance, a ready-made set, which has only one version of the assembly, will develop little creativity and will not allow a better understanding of physical phenomena.

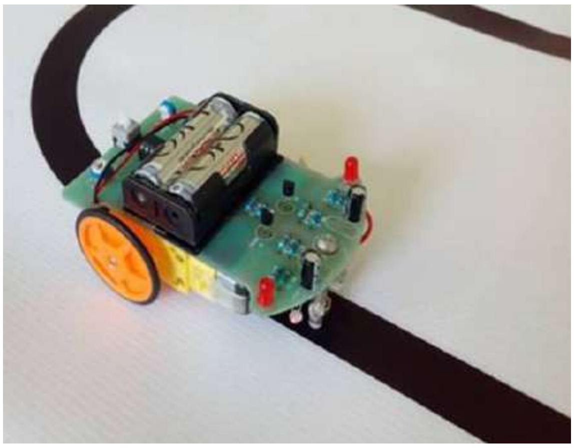

Figure 1: Robot D2-1 on the track.

But it should be noted that children working with such a set have the opportunity to work with the electronic circuit and its components, learn to work with a soldering iron, develop skills to adjust the operation of electric motors. Also, the creativity of the pupils of the afterschool activity allows to improve the ready-made basic model. So one of the improvements was the addition of a photoresistor and LEDs to the Arduino board, which in turn expanded the capabilities of the device: when the robot enters a darkened area of the room, the light is automatically turned on. This feature can be used on cars to automatically turn on the light when entering a tunnel or other dimming. Thus, a simple radio constructor allows students to have practical skills in working with radio circuits, and the device itself can be an example of photoresistor when studying the topic of "Semiconductors" in physics lessons, as coordination is provided by changing the current in the photoresistor.

Another project that was initially carried out according to ready-made instructions is a meteorological station (figure 2), which measures temperature, humidity and atmospheric pressure. In 10th grade, students study the topic "Fundamentals of molecular kinetic theory. Fundamentals of thermodynamics", so it is convenient to interest this age category in the implementation of such a project.

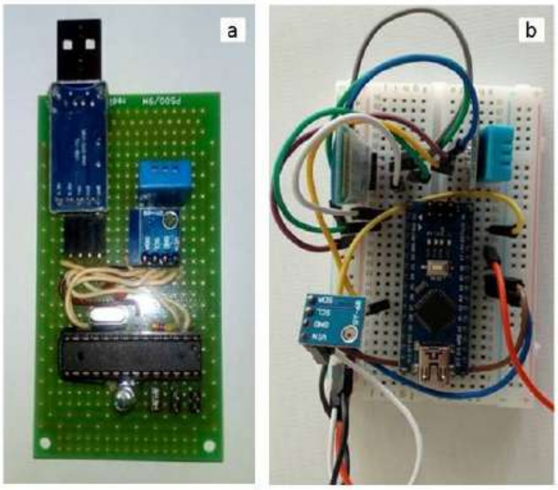

Figure 2: Meteorological station: a) with Atmega8 chip, data transmission via wire; b) with Arduino Nano board and wireless data transfer.

As part of the above topic, children learn concepts such as temperature, humidity and pressure. Physical experiments to measure these quantities are in the program of the physics course, so the manufacture of the device will not only develop the engineering skills of students, but also strengthen the material base of the physics classroom and bring the school physical experiment to a new level.

The meteorological station made by the students did not initially have an Arduino board in its design, but worked on the basis of the Atmega8 chip (figure 2a). But the student who worked on the project suggested her own design of the device (figure 2b), which not only works from the Arduino board, but also transmits data at a distance of up to 60 meters using a Bluetooth device.

It is very important to involve students in teamwork, so continuing to look at the weather station, we can give an example of a computer science project that has improved the measurement efficiency of the above-mentioned device. Another student developed an application for a mobile phone (figure 3), which displays the results of measurements, as well as allows you to save and view them. In this way, cooperation develops students' ability to work in a team and brings them closer to the realities of life, because large and complex projects are not performed by one person, and the end result depends on the interaction of the team.

Figure 3: The meteorological station – an application for a mobile phone.

Another project the students were working on was the Equal Acceleration Study. The purpose of the project is to measure the time of evenly accelerated body movement. In conventional studies, time measurements are performed using a mechanical stopwatch. As a rule, the measurement of time itself gives the greatest error in human factor studies (the timing of the stopwatch on and off). The measuring device (figure 4) was assembled on the basis of the Arduino UNO board and its compatible elements: the actuator and the button. This device allows you to measure the travel time up to a microsecond. The measurement results can be seen on the LCD connected to the board. Such a device can be used in laboratory work with the topics “Determination of acceleration of equal acceleration of movement” (10th grade), “Determination of average speed of movement” (7th grade), “Determination of acceleration of free fall” (10th grade).

Figure 4: The stopwatch to measure the time of uniformly accelerated motion.

The device for measuring the time of accelerated motion (figure 5) consists of an Arduino UNO card, LCD display, servomotor, button, remote control, infrared receiver, chute, ball and tripod with holder.

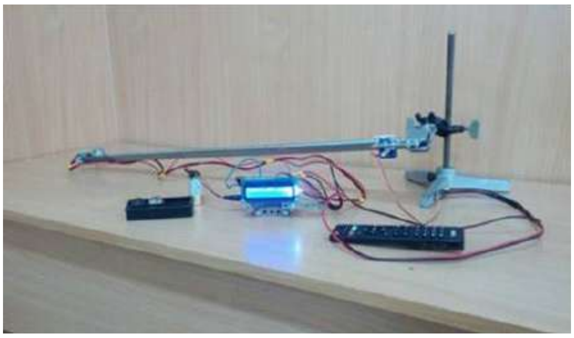

Figure 5: Installation for measuring the time of uniformly accelerated motion.

The measurements are as follows: The Arduino board is connected to the power supply; the ball is set to the starting position; at the remote control press the start button at this moment the servo is turned to 900 and the program loaded into the board begins the countdown; when the ball reaches the button, when pressed, the countdown stops and the fixed time can be seen on the display; return the servomotor to the starting position with the help of the control panel; further the following experiment can be performed. Usually at laboratory work the ball is released by the hand and try to turn on the stopwatch synchronously, and stop the countdown when hitting the ball against a metal cylinder. It is these actions that lead to a great deal of error when doing research. The results of the studies are shown in tables 1 and 2.

Table 1: Measurement of time of uniformly accelerated motion in the classical way.

No	**t, sec**	**t(av), sec**	**error, sec**	**relative error, %**
1	1.46	1.48	0.02	1.35
2	1.35	1.48	0.13	8.78
3	1.40	1.48	0.08	5.40
4	1.47	1.48	0.01	0.67
5	1.37	1.48	0.11	7.43
6	1.63	1.48	0.15	10.13
7	1.48	1.48	0	0
8	1.62	1.48	0.14	9.45
9	1.63	1.48	0.15	10.13
10	1.45	1.48	0.03	2.02
			maximum error 10.13 %	

Table 2: Measurement of acceleration time using an Arduino-based device.

No	**t, sec**	**t(av), sec**	**error, sec**	**relative error, %**
1	1.432	1.458	0.026	1.78
2	1.489	1.458	0.031	2.12
3	1.458	1.458	0	0
4	1.455	1.458	0.003	0.2
5	1.468	1.458	0.01	0.68
6	1.430	1.458	0.028	1.92
7	1.442	1.458	0.016	1.09
8	1.486	1.458	0.028	1.92
9	1.457	1.458	0.001	0.06
10	1.469	1.458	0.011	0.75
			maximum error 2.12 %	

Studies have been shown that the measurement results obtained with an Arduino-based device have an error of five times less than the results obtained with the classical measurement used in laboratory work. It can be concluded that the use of microcontrollers can improve the quality of the experiments.

This setting can also be used to measure free fall acceleration. To do this, simply attach the sensors on a tripod along the vertical line (figure 6).

In addition to producing a pre-fabricated installation, working on the project, the students conducted research whose content went beyond the curriculum of the profile school. To investigate the value of free fall acceleration, five balls of different masses were taken (figure 7).

The scientific research method used for this is called extrapolation. Throwing in the air all the balls in turn, you can get the value of the free fall acceleration in vacuum, extrapolating the dependence of this

Figure 6: Installation for the acceleration of the accelerated fall.

acceleration for each ball in the air on the inverse of their mass. That is, it is possible to determine the acceleration of free fall for a ball of infinite mass, and in this case it is possible to neglect the resistance of air to the ball. As bodies with different mass used ordinary table tennis balls with a diameter of 40 mm.

In order to measure the time of falling of different balloons by weight, it would give the most accurate result, it is desirable to achieve the greatest difference in the masses of balloons. For mass change, they were filled with different material (figure 7). Therefore, the lightest used ball is empty and the hardest filled with metal with small nails. The masses of the balls were in the range from 3 g to 40 g.

A servomotor with a tube fixed by the holder (figure 6) was attached from above to a regular school tripod, a mechanical button was attached to the bottom, on which the ball would fall. With the help of movable holders you can change the distance from the point of launching the ball to the button, experimenting with different height of fall. To insert the ball into the button, and to prevent the heavy ball from breaking into the iron holder and the floor, a shield is attached to the button. Studies have been shown that the measurement results are not affected by the shield.

After adjusting the device so that the ball falls exactly on the button without the slightest deviation, measure the distance and determine the time of free fall of the balls. Studies have shown that the time during which the same ball falls from its average by approximately 5 ms. This is due to the fact that the ball, falling downwards, may deviate from the vertical on which the central axis of the installation is located, due to the moving air flows, or if the tripod oscillates slightly at startup. Deflecting the ball each time falls into a point different from the button on the shield, which causes a time delay. Also the reason for the different values of time is that the Arduino processes the information coming into the payment processor at different times, which causes the timer on the device to work with delays. To minimize the time discrepancy, we performed 15 measurements for all five beads and determined the average fall time. They also set an average delay of 8 ms due to microprocessor processing.

Taking into account the above, and having worked out the results of measurements, we determined the acceleration of free fall in vacuum for the study room of physics. The obtained value of the acceleration of free fall in vacuum was equal to 9.8093 m/s^2. The research was presented at the competition for the protection of research works of the Dnipropetrovsk Department of the Junior Academy of Sciences of Ukraine, the student who conducted the research was highly praised by the jury and won the competition.

5 CONCLUSIONS

Students worked on the above projects under my guidance. All manufactured devices work and are used in teaching children. These examples demonstrate the possibility of using microcontrollers and compatible sensors during individual and team work of children, for the manufacture of simple devices according to ready-made instructions and devices that allow scientific research, for the manufacture of toys and measuring instruments used during physical measurements.

With regard to physical measurements, it should be noted that the use of automated devices is only appropriate for measuring some physical quantities, and should not be replaced by all classic measuring devices. For example, when performing laboratory work on the topic "Determining the acceleration of accelerated motion" in grade 10, you need to measure two values – time and path. To measure time, it is advisable to use the above-mentioned device instead of a stopwatch, since the human factor gives a significant error that cannot be calculated in the future, and the use of a ruler makes it possible to make accurate measurements, to calculate the measurement error, and to improve the ability and skills to measure length (width, height, path, distance, etc.). Also, when measuring humidity, it will be correct, based on the results of measurements of relative humidity and temperature, to ask students to determine the absolute humidity.

Therefore, the use of the Arduino hardware and

Figure 7: Manufacture of balls to measure the acceleration of free fall.

software in educational and research activities is an effective tool for increasing interest in such areas as computer science, engineering, and physics. A comprehensive approach will allow students to be interested in the science of mathematics, solve modern problems of engineering and electronics, as well as develop their creative abilities. Working on your own projects allows children to showcase their abilities and present their projects at various competitions, which further motivates young researchers. The devices developed by the students allow to significantly improve the accuracy of measurements during the experiment, increase the level of theoretical preparation for laboratory work, increase the general interest in the laboratory work by the students by modernizing the equipment and form new ideas about phenomena and processes of physics.

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Social Media as a Strategic Tool in School Management: Experience of Ukraine and USA

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Keywords: Social Media, School Management, Massive Open Online Courses (MOOC), School Leaders, Management of the Educational Institution, Certification Training.

Abstract: The article presents the results of the analysis of using of social media in school management in Ukraine and United States of America. Social media is broadly defined as a lot of relatively inexpensive and widely available electronic instruments that allow any person to publish and receive information, collaborate and build relationships with other people. The authors of the article break up social media into social networks, blogs, content hosting. There are some constructive conclusions made in the article. The educational opportunities of social media among Ukrainian specialists are very underestimated. The value of social media as an instrument of the educational process is undeservedly belittled. Many educators treat them with neglect and skepticism, considering social media exclusively as an entertaining resource. Using of social media for educational purposes is perceived by American students, teachers, researchers as self-evident and inalienable function. The American didactic experience reveals that social media can be successfully used to arrange the work of the teaching staff and students, hold individual and collective consultations enhancing intellectual and creative potential of students. The data reports "Global Guide 2020", "90 days that changed K-12 teaching & learning: strengthening the bonds of communications", "2019 Social Media Trends in Education Report", "Digital learning during the pandemic: Emerging Evidence of an Education Transformation" and the Ukrainian State Education Quality Service for 2020 are analyzed in the article. The authors had a content analysis on the massive open online courses (MOOC) by the Ukrainian platforms EdEra, Prometheus and VUM online and the English ones such as edX, Udemy, FutureLearn, XuetangX and Coursera, whose self-study contributes to the readiness for the effective using of social media in school management.

1 INTRODUCTION

The modern period of development of school management is characterized by the active and comprehensive implementation of information and communication technologies. The main goal of their implementation is the improving the quality of training and the interaction of all participants in the educational process.

The social media grows in popularity all over the world. According to a new research by GlobalWebIndex (www.gwi.com, 2021), people expend a third of their network time in social media. Comscore data also shows that percentage of time spent on social media and messengers accounts for more than a quarter of time spent on their mobile devices.

Social media is growing rapidly and becoming a social force with a life of its own, offering us the immediacy and availability of information and data and the immediacy of people, conversing and working together in areas of common interest.

1.1 Related Works

Kaplan and Haenlein (Kaplan and Haenlein, 2010) gave a definition to social media as "a group of In-

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ternet applications basing on the ideological and technological foundations of Web 2.0 that allow to create and share user content". Web 2.0 is a tendency to develop websites on the similar principles stemming from the focus on the project and service socialization, its improvement by users (O'Reilly, 2005). Social media is fundamentally different from traditional types of media by implementing a bidirectional information transfer strategy meaning "many sources and many recipients" (Scott, 2017). Traditional media, in its turn, uses a unidirectional strategy meaning one source and many recipients.

There is no generally accepted definition of the term "social media". In our opinion, the most concise, simple and relevant definition of this phenomenon is: "Social media is broadly defined as a lot of relatively inexpensive and widely available electronic instruments that allow any person to publish and receive information, collaborate and build relationships with other people" (Education World, 2012).

Social media is an online communication in Thornley (Thornley, 2008) terms with express understanding that a person can smoothly and flexibly change their role, to appear either as an audience or participant. Social software is used for this purpose which makes it possible anyone (without specific coding expertise) to post, comment, move, edit information, create communities on their interests.

Stephens (Stephens, 2011) defines social media as "forms of communication either Internet or text-based that support social interactions of individuals".

Azhnyuk (Azhnyuk, 2012) defines social media as an online service intended for the mass distribution of user-generated content, wherein anyone could be an author as opposed to traditional media wherein authors are pre-selected and limited audience.

Some researchers consider the concepts of "social media" and "social network" as synonymous. However, we feel that this is incorrect. We are on board with the statement of Scott (Scott, 2017) that "social media is a superset and social network is a subset". Thus, social networks are just a specific instance of social media albeit the most popular one.

Azhnyuk (Azhnyuk, 2012) breaks up social media into 3 categories: 1) social networks; 2) blogs (including standalone, blog hosting, microblogging, etc.); 3) content hosting (photo services like Instagram and Flickr, video hosting services like YouTube, hosting for slides, documents, music like Slideshare, Scribd, Soundloud, etc.). However, he notes that online media intended for personal contact or group communication, rather than for mass publication should not be relegated to social media, in particular, e-mail, messengers, online games.

Zhdanova (Zhdanova, 2019) identifies 7 types of social media:

1. Social networks are online services that prompt you to make new acquaintances and form interest communities. A user has an online profile and several ways to interact with others (through groups, events, polls, games, etc.) on such sites. Facebook and LinkedIn are the most famous examples of social networks.
2. Messengers are online messaging services where users interact through personal correspondence. Messenger applications are available on mobile devices such as Telegram, Viber, WhatsApp.
3. Social bookmarking sites help users save and share interesting information as a link to other resources. For example, the Pinterest network allows you to store a large number of images in different categories in order to facilitate the search later.
4. Blogsand forums offer comments to many users at the same time. Medium, Blogger and WordPress are well-known blogging platforms.
5. Microblogging lets you send short updates (140 characters) to everybody subscribed to such updates. The most outstanding microblogging, Twitter, has gained a lot of attention among journalists, as it allows you to quickly track developments and get information on what's happening on the spot.
6. Social news services allow users to create or publish links to news from other sources. The main element is voting, the community chooses this way which news will become the most important and visible to the rest of the users. The most famous example is Reddit.
7. Multimedia hosting is services possessing most of the social network peculiarities (user profile, circle of friends, opportunities to ditribute and comment on information), but it is primarily focused on the ability to download video, photo and audio files. Examples include YouTube, Vimeo, Flikr.

1.2 Social Media in Educational Management

One key task of the educational management is to ensure the development of the educational institution as an independent organization through establishing interaction with all participants of the educational process, partnership with public organizations and support of local business. Relationship networks take a position of one effective interaction model for all participants of the educational process. Skills of active communication through social networks are currently necessary for everyone. Facebook, Twitter, YouTube and other networks have moved beyond a framework of face-to-face interaction and it is powerful communication platforms facilitating both to build your brand and be a virtual representation for government, business, and public organizations.

Unlike the official websites of general secondary educational institutions requiring training in a more professional way for updating information and establishing feedback, the pages of institutions in social media have their own characteristics determined by the properties of electronic communication as prompt dissemination of information, accessibility, simplified search the target audience, ease of the feedback set up and so forth. It has own structure, organizational and technological parameters affecting the nature of social connections and being an element of the constructing mechanism for the communicative space within modern society, performing several functions while creating a value basis of its existence.

Primbs (Primbs, 2016) identifies key needs for users in social media:

- managing relationships from Facebook dating as a replacement for exchanging visiting cards to close contacts in the family or community of friends;
- managing information by filtering news and relevant information based on user preferences through friends and subscriptions;
- managing one's identity by forming a personal brand.

For the foregoing reasons a follower of the website of the educational institution or school principal having independently joined a school community on social media is in position to:

- establish contacts between the participants of the educational process and to terminate communication without explanations at any moment;
- set up constant access to information on news of the educational institution activity due to the operational aspects of search algorithms of social media;
- develop own attitude to certain events in the educational field relying upon an opinion of the experts of the ultimate educational brands. It means that actual attitude of the experts to a particular educational institution and a vision for the further developments is relevant for the followers rather than the information in itself under the context of big data on educational reforms reported by thousands of sources.

Thus, for the head of an educational institution, the presence on the social network personally or through the institution's page allows to promptly inform the participants of the educational process with the life of the organization, purposefully manage the flows of various information, influence their consciousness and worldview transforming parents from "readers/observers" to active coexperiencers/fans or vice versa, however, awareness ensures that the negative developments of individual autonomy are reduced.

Returning to the (Primbs, 2016), the role of fans should be emphasized: "Real fans are much more than mere readers/listeners/viewers/target group, fans interact. Fans are ready to do something for the object of their worship. Fans are the first to submit photos when you are announcing a photo contest. Fans write the first comments under your posts breaking the ice. Fans cut trolls down to size excusing from a nasty work. Fans will also stand with you when you get a shitstorm. They provide entertainment for regular visitors of your community. And they give you stuff you can work with again".

The communication efficiency on the network is manifested by a high level of trust within the network, as opposed to distrust of external persons; existence of a unifying ideology/religion/lifestyle that allows to act together; targeted message delivery, which make possible it to be received precisely by the person who really needs it, as opposed to communication with a mass but passive audience in the case of traditional media (Pocheptsov, 2012). These are mechanisms for the group functioning that ensure the integration of individual actions in joint group activity and communication.

One of the crucial components of the management process in an educational institution is to inform participants of the educational process and communities on its activity in open public resources (Bobrovskyy et al., 2019).

2 RESEARCH METHODOLOGY

The pedagogical research under consideration has been carried out as part of the research work "Training of competitive specialists in the context of educational changes" (RK 0117U002378) to be conducted in 2017-2021 by the Department of Pedagogy, Administration and Social Work of the Educational and Scientific Institute of Management and Psychology of the University of Educational Management of the National Academy of Educational Sciences of Ukraine.

The aim of the article is the comparative analysis of features of using of social media in school management: experience of Ukraine and United States of America.

We monitored 120 sites of Ukrainian middle schools and 123 sites of American schools (several sites from each state).

The monitoring parameters are:

- which social media do principals use in managing of the schools, teams of teachers and students?
- what are the purposes of using social media?

Also we monitored the pages of Ukrainian and U.S. principals in social networks.

We conducted a survey of 138 school principals of Ukraine. The key survey questions were:

- do you have a personal page in social networks?
- does your school have its own page in social networks?
- what social networks do you use in your managerial activities?
- are there any barriers to school communication in social networks?
- which information in social networks is the most interesting for participants of the educational process?

We had a content analysis on the massive open online courses (MOOC) by the Ukrainian platforms EdEra, Prometheus and VUM online and the English ones such as edX, Udemy, FutureLearn, XuetangX and Coursera, whose self-study contributes to the readiness for the effective using of social media in school management.

We have also used the online survey results of 3,9 thousand principals of general secondary educational institutions, educators, parents and the students from 9–11 grades on the distance learning in schools of Ukraine that was conducted by the State Education Inspectorate of Ukraine in the period from April 8 to 15, 2020.

For comparison we took the results of a survey of American school principals from the report at the official website of U.S. Department of Education "Social media in school emergency management: Using new media technology to improve emergency management communications" (Stephens, 2011), the report of Pew Research Center "Social networking fact sheet" (Pew Research Center, 2018), reports "Global Guide 2020" (EducationUSA, 2020), "90 days that changed K-12 teaching & learning: strengthening the bonds of communications" (tomorrow.org, 2020), "2019 Social Media Trends in Education Report" (classintercom.com, 2019).

3 RESULTS AND DISCUSSION

Using social media, the schools can:

- quickly respond to the needs of the audience: hear the parent, student and the public community (highlight the main topics for discussion, get feedback);
- prevent conflicts due to operational coverage of problems in the activities of the school;
- through social networks learn more about the activities of other schools and build own strategy for activities in social networks;
- fill vacancies and provide the school with highly qualified personnel by searching for personnel in social networks. For example, the group "Jobs for educators" on Facebook. The goal is to post messages about available vacancies in schools and for teachers which find work.

In the school social media are primarily an external communication tool. For large schools with a large number of participants in the educational process, social media can be a tool for interaction between participants in the educational process among themselves (for example, quickly obtain the necessary information and provide mutual assistance). The social media allow to the teaching staff, and especially to the director, to quickly resolve issues related to the adaptation and rotation of personnel.

We obtained the following experimental results (table 1).

Most principals avoid committing to the professional use of social media because it's completely overwhelming. Between Instagram, Twitter, YouTube, and Facebook etc., it is hard to know what will yield the best results. It's important to consider the best social media for purposes.

Every principal tries to choose the best way to promote wonderful school community. For learning and interacting, the American principals of middle schools use Twitter. It is the gold standard for them. For documenting and sharing the cool work happening in school, Instagram and YouTube are the best and most popular tools. Flickr is useful for sharing pictures. American principals of middle schools use Facebook for calendar reminders and getting the word out quickly about calendar changes and events planning.

For example, the school principal Eric Sheninger, 2013 American "Best Director Award" winner, bestselling author of "Digital Leadership: Changing Paradigms for Changing Times" (Sheninger, 2014), allowed his teachers to submit their daily reports using blog. Sheninger's blog was viewed by 6,500 peo-

Table 1: The results of monitoring of the use by school principals of social media in school management (2019 year).

Social media	The results of monitoring of Ukraine	The results of monitoring of the USA
Facebook	96 %	98 %
Instagram	33 %	87 %
Twitter	1 %	99 %
Telegram	10 %	-
WhatsApp	4 %	76 %
Viber	36 %	11 %
Youtube	25 %	84 %
Linkedln	-	28 %
Google Blogger	5 %	87 %
Google+	5 %	89 %
Pinterest	7 %	56 %
Skype	12 %	42 %
Flickr	-	63 %

ple worldwide and over 600 are constantly following the life of the principal and his school in September 2019. It is interesting that it was an incentive not only to report to the administration on their work for teachers, but also to share with others the experience they have gained by introducing gadgets into teaching, as well as the success stories achieved by the students in these lessons. The topics of blog posts began gradually to expand, teachers shared the system of grades in school, their rubrics, how they interact with children outside of school, how the use of gadgets improves academic performance, and so on. A new perspective on education and blog creation has transformed the lives of teachers and students. Firstly, the US government purchased the latest equipment at the school Eric Sheninger writes proudly about on his blog (Sheninger, 2014). Secondly, teachers from all over the world came to the school in New Jersey to learn about the experience. In addition, the virtual reality company provided a program that allowed New Milford school students and their teachers to attend virtual space meetings where children could ask questions, and virtual training courses were provided.

The principal of Renner Elementary School Teresa Tulipana embraces the social media as a communication tool. Facebook and Twitter accounts keep families abreast of school events and happenings. She envisioned them as systems to provide calendar reminders. She thinks the Facebook is also a great tool for sharing our school's academic and behavioral focus areas in an efficient, fun and engaging manner. Recently a kindergarten teacher posted an Animoto highlighting pictures from Writer's Workshop, which communicated the importance of writing at our school. When the fourth grade completed Famous Missourian research projects, these were posted so parents were able to understand the value and im-

Table 2: Comparative analysis of the goals of using social media in school management in the USA and Ukraine (2019 year).

The goals of using social media in school management	The purpose rating of Ukraine	The purpose rating of the USA
Simplified search for the target audience allowing to expand personal and professional contacts between participants of the educational process	1 (90 %)	3 (87 %)
Demonstration of educational measures	2 (70 %)	4 (85 %)
Public disclosure of successes of students, teachers and school classes	3 (62 %)	1 (99 %)
Public disclosure of urgent announcement	4 (57 %)	2 (98 %)
Demonstration of various forms of training	5 (49 %)	6 (76 %)
Project and competition reporting where both students and teachers can participate	6 (43 %)	7 (62 %)
Clarification on the issues of the educational process (school enrollment, standardized external testing, state final examination, etc.)	7 (41 %)	8 (39 %)
Explanation of educational reforms and innovations	8 (33 %)	9 (11 %)
Challenges of participants of educational process consolidation concerning engagement in socially important projects	9 (17 %)	5 (81 %)

portance of their research. Social media has also allowed to deploy important professional development content in Renner Elementary School. Recently they used Blackboard, an educational social media tool, to host a virtual faculty meeting. Through Blackboard, staff watched a short Rick Wormeli video on defining mastery, and then responded to reflection questions on a discussion board. This flexible format allowed staff members to learn at a time that was convenient to their own personal calendars and increased engagement by assuring that every voice was heard (Education World, 2012).

The principal of Tomahawk Creek Middle School says that the teachers of her school utilize social media whenever they can. They currently have a Facebook page for school and PTA. She have found that this was a great way to get messages out to parents and students. There are several teachers who use Edmodo to post discussions and assignments for their students, and they have reported remarkable success using this tool. For example, one teacher had 25 kids on Edmodo the day he started using it. They are looking at implementing a Twitter account next year to help get information out to the community. Although this is not a replacement for standard means of communication (Web sites, letters home, etc.), it is a great additional way to share information with community. As far as discipline issues go, they attempt to address those who cause the issues. The technology is here to stay, so they try to implement it where they can and deal with the trouble issues when they arise. Thus far, they have had no problems using these means of communication (Education World, 2012).

Principal of South Side Elementary School in Bristol, Connecticut, David Huber thinks that Twitter is more than just a social media platform. It’s also a professional learning resource, a tool to communicate with students’ families, and a way showcase student achievements (Friedman, 2019).

One area of the social network usage being actually the origin for its popularity in Ukraine was the involvement to solve socially important issues of participants of the educational process. In particular, Facebook has been used to inform, mobilize and raise funds for volunteers during the Revolution of Dignity since November 2013. Therefore, the school administration resorts to this tool in order to continue this work to assist and support the ATO warriors and report on the done work. In addition, content analysis of the pages of the administration and teachers of educational institutions of Ukraine shows the effectiveness of similar charitable work in collecting assistance among participants in the educational process supporting socially disadvantaged sections of the population or volunteers as orphanages, elderly people, rural libraries, hospitals, etc.

In addition to it, not only prompt information but also targeted support directly to the participants of the educational process are provided through the Facebook network and messengers, among which Viber is the most popular for the management of the educational institution. It is about involving a large number of indifferent people to help the participants of the educational process who were in an emergency like fire, accident, surgical treatment, etc. Such assistance massively reduces fraud and disillusionment with charities through direct personal contacts.

Another example of the social networks usage in the school management is the establishment of successful cooperation and communication between educational institutions of municipal ownership and its public within the framework of project activities aimed at repairing or arranging the territory and premises of educational institutions, as well as buildout of a creative, development or inclusive environment. The key to the success of such projects is the proper organization of its advertising on social networks by the author of the project, in particular, the administration of the educational institution, as well as high activity of participants in the educational process to support projects in social networks. 663 educational projects have particularly won according to the results of the “Public Budget 2020” project out of 1564 projects in 13 categories having passed the stage of planning and implementation in Kyiv that, which is 42 % of all projects (gb.kyivcity.gov.ua, 2019).

Nevertheless, social networks are equally threatening. The freedom of the information distribution through social networks and communities regardless of its content and quality particularly transforms the virtual Internet space into a risk zone for the spiritual and moral sphere of the individual shifting classical values and developing a new virtual culture.

An interesting transformation was occurred to Facebook community “Parents SOS” founded in June 2014 due to the initiative “talk on the social network” in order to discuss problems related to education, assistance to parents in the case of mistreatment of their children in school or kindergarten and initiate systemic changes in education.

The community works according to a simple plan:

1) the situation is announced (at school or in education in general);
2) it is discovered how this situation complies with the law;
3) the conclusion what should be changed whether the situation or the legislation, and they change it together.

Despite the fact that the public organization initiated many changes in the education system through civic initiatives during the its existence, its members often resorted to systematic violation of netiquette, resorting to rude, obscene, evaluative expressions and personal affront in the beginning. Instead of solving a problem, sometimes it was possible to be sunk in the information rain of value judgments supporting a particular message have not received a solution to the problem in the real world.

It should be noted that the group's administrators are currently working hard to address these shortcomings, as evidenced by the article's content analysis of the group's 2019 publications. In particular, publications are increasingly focusing on situations of success as systemic changes, concrete victories over bureaucracy in education and extortion; legal clarification of the rights and freedoms of participants in the educational process; clear algorithms for solving the most common educational problems for all participants.

So we have determined grounding on our analysis that the following types of social media are the most popular for USA and Ukrainian school:

1. *Blogs.*

   A blog is a 21st century newsletter. Blogs provide a two-way interaction and allow the school administration to integrate multimedia content in order to make the school popular. There is no better way to share strategies, ideas and success stories. Teaching blogs are no less popular, with the help of which teachers can effectively manage the independent extracurricular work of students, as well as create tasks aimed at improving the skills of speech activity. Learning different types of letters (search, viewing, familiarization and studying) is facilitated by the unlimited ability to post links in any quantity to materials different from each other. Also, blogs are in no way inferior in the possibility of acquiring speaking and listening skills. This happens through the use of podcasts, through educational texts of radio programs, and videos that are freely available on the Internet. Integration of all the listed training methods into a blog allows you to listen to files repeatedly, and if necessary, stop and revise files. American Schools use Google Blogger, Wordpress, Edutopia (San Rafael, California), FreeTech4Teachers (Maine), Rubicon (Portland, Oregon), Hands On As We Grow (Iowa), Class Tech Tips Blog (New Jersey), The Applicious Teacher (Orlando, Florida), Teaching Heart Blog (Pittsburgh, Pennsylvania) and other platforms. For example, Eric Sheninger in addition to his official blog as Principal of New Milford (Sheninger, 2021), has created a professional blog to tell the story of the digital transformation of the school and learn from others interested in digital leadership.

   There are a number of impressive blogs by heads of schools in Ukraine on the Internet, the number of which is impressive. In particular, the Google request "blog of a school principal" represents 19 million search results. However, it should be understood that the use of blogs in the management of general secondary education is often due to external circumstances as a requirement for certification. For this reason, the Internet is full of blogs formally created with the glut of popular articles, elements of plagiarism or unstructured content. Quality content could only be seen by those executives who are passionate about this type of work and update the materials systematically. However, interviews with more than 400 education executives show that blogs in Ukraine are currently an outdated tool and can be completely replaced by social networks. Therefore, a mere 5 % of heads of our online respondents use blogs in their management activities.

2. *Digital photo sharing.*

   Photos can quickly depict and share student work, improvements and achievements. American and Ukrainian school principals and teachers take pictures of student projects and then post it on Instagram. American teachers also use Pics4Learning during classroom observations. They share photos with other accounts such as Twitter from their Instagram account.

3. *Video platform.*

   Creating a YouTube, TeacherTube, SchoolTube channels or Vine account for school allows you to record and share educational and social processes. Teachers and administration of American schools share live events such as school concerts in real time using such tools like Ustream, ClassVR etc. In Ukraine the principals use YouTube.

4. *Twitter.*

   Twitter, the best-known free microblogging application, is particularly useful for fast exchanges of thoughts, ideas, and information. American scientists were among the first users of the social network Twitter. During the first years of existence, it was dominated by reports of scientific conferences, symposiums, research citations, etc. 140-character tweets are a dynamic combination of text, images, videos, and website links. Having created a hashtag for the school you could share a conversation with related parties with the ability to search for any problematic topic identified through Twitter. At the beginning of each school year American school leaders send parents a letter describing, how to create a Twitter account and to set up options for receiving text messages. Ability to receive Twitter updates on its own terms makes it unlike any traditional communication tool (Scott, 2017).

5. *Facebook.*

   World famous resource Facebook has emerged as an academic social network. Initially the website was available only for students at Harvard University. Then registration was opened to other universities in Boston, and later for students of all educational institutions in the USA. All the above tools could be integrated or published on the Facebook page (Thornley, 2008). It is the favorite social media among Ukrainian and American school principals and teachers.

It is impossible to create and maintain confidence in the operation of the institution being a mandatory. It is impossible to create requirement for effective educational activities without prompt and complete information. That is why the administration should organize the activity of the educational institution under the conditions of information openness and communication with the participants of the educational process and the community.

Information transparency is ensured by the availability of educational facilities including social networks Information transparency in the educational institution to inform the participants of the educational process. The educational institution decides itself what to inform of and how to do it additionally. The primary principle of information distribution is to report important data for parents who are the most concerned and critical audience.

It is for the purpose of enabling local educational managers to communicate quickly, correctly and clearly, not to be afraid of criticism and be able to turn to crisis situations, an online course "Effective Communications for Educational Managers" has been developed by the public organization "Smart Education" powered by the EdEra online platform (EdEra, 2019) and viewed by 4,400 people during 10 months of 2019.

In order to be successful communicators in the modern information space, its developers offer:

- be persistent and consistent in sending a message, ideas and facts, the audience will be grateful for accurate navigation in the chaos of educational information;
- repeat the message many times in different formats through interviews, events, photos, infographic, etc aiming to be heard;
- know what bothers and what interests your audiences, and build your business and communication against this background;
- always keep efforts and resources on the mission of the institution;
- focus on the simplicity and clearness of messages;
- have unique inspirational stories;
- get your audiences as close as possible.

Much attention is paid to anti-crisis communications, which goal is to immediately and firmly abandon attempts concealing any unpredictable or even unpleasant event in the educational institution. The overall penetration of modern communications into the public life makes it absolutely impossible to conceal any information. One of the primary principles of public communication should be remembered: a person first reported the event largely determines the further development of its media coverage.

The unpredictable event message should consist of three required components answering the following questions:

- "what happened?" – provide full information on the event, immediately blocking or at least substantially reducing the possibility of misinformation on it;
- "what are we doing?" – the school demonstrates its proactive stance in addressing the problem, what has been taken to remedy the problem, who have been further involved and informed;
- "what to expect?" – an uncomfortable state of uncertainty is removed or at least significantly reduced for the person, the most probable developments are shown.

Lastly you should always report how the problem is resolved. Given that, you also should be frank, and if the problem cannot be finally resolved for some reason at the school level, then it should be obligatory revealed and reported on further steps to resolve it (Kobernik and Krasnova, 2019).

Since information distribution and communication are grounded on the processes of dissemination and exchange of information, it is important to know how these processes are implemented and how they can be effectively organized. Building quality information distribution by the head to the participants of the educational process and the community can contribute in many ways to improving the level of media literacy of the administration and teaching staff of the institution.

The characteristic of social networks particularly has the underside in the rapid and prompt dissemination of information. A prime example is sharing of "innocent" fakes at the request of the school administration with good intention of preventing the consequences of participation in the games "Blue Cat", "Run or Die", "Momo", "Candy" and a new game "Bounce!" through social networks by parents. Low media literacy of participants of the educational process, lack of ability to recognize the signs of fake news, poor orientation of critical perception of information contributes to the testing parents of various technologies of measuring the status of the audience and channels of information dissemination on social networks.

Information security should start with every participant in the educational process, especially with the school administration, and it should become a daily habit for us not to become the object of fake dissemination, a tool for the introduction of dirty technologies, a convenient toy in the game of manipulators. Such results are summed up in their posts by Ukrainian media educators Inna Ivanova (review of the "Candy" fakes, September 2018) and Svitlana Izbash (review of the "Bounce!" fakes, February 2020) hereby preventing parents from "advertising" such games.

The school principal should also consider other types of danger that students may encounter using any network and that should be taken into account in the institution policy:

- content (access to information not intended for children of appropriate age);
- behavior (offering actions that could endanger child safety, fraud);
- dangerous contacts (chatting, file sharing, messengers).

In order to avoid such risks, a school principal should develop his own policy on the safe use of the Internet, which provides:

- content filters;
- availability of antivirus programs and its timely updating;
- use of Internet resources during training sessions under the teacher control;
- monitoring the page on social networks with respect to placing unauthorized information on it;
- providing educators and students with training on safe use of the Internet and development of end-to-end information and digital competence;
- online culture enhancement of the communication participants of the educational process;
- preservation of personal data of participants of the educational process (Bobrovskyy et al., 2019).

4 CHALLENGES THAT SCHOOL LEADERS FACED DURING THE PANDEMIC

School leaders' roles have been unexpectedly and dramatically changed by the COVID-19 crisis. The unprecedented nature of this situation means there is no set direction for them to follow. School leaders are like actors in a play where the story, the script and costumes have all changed mid-performance, and they are on stage improvising to adjust to their new role (Sampat and Oommen, 2020).

The forced mass introduction of distance learning technologies during the pandemic (Polhun et al., 2021) has exacerbated the issue of using of social media in school management.

In the period from April 8 to 15, 2020, the State Education Quality Service of Ukraine conducted an anonymous online survey of 3.9 thousand school principals, 43.4 thousand teachers, 120.5 thousand parents and 44.1 thousand students of 9-11th grades (sqe.gov.ua, 2020).

From the point of view of our research, we were interested in the results of a survey of principals, who make up more than 25% of school principals in Ukraine. 49.95% of them work in rural areas, 41.98% – in cities and 8.07% – in urban settlements.

Most parents and students in grades 9–11 who participated in the survey confirmed that for the period of quarantine there is distance learning in all subjects of the invariant component:

- 102,380 parents (85%);
- 36,425 students (83%).

The directors of general secondary educational institutions also assured that 97% of educational institutions for the period of quarantine teach students using distance learning technologies. The preference for distance learning is divided in half:

- 55% of surveyed students (24,087 people) and 50% of parents (60,569 people) were positive;
- 45% of students (20,001 people) and 48% of parents (57,858 people) gave a negative response.

After completing the quarantine, 41% of the surveyed teachers (17,872 people) indicated their desire to use distance learning technologies, including social media, and 54% (23,397 people) would use them partially. Only 5% of teachers (2,096 people) stated that they would not turn to distance learning technologies in the future.

The results of the survey of principals also confirmed that almost 96.9% of general secondary educational institutions (GSEI) during the quarantine period students are taught using distance learning technologies. The majority of leaders (75.9%) noted that the entire teaching staff was involved. However, in almost 20.1% of schools, distance learning is provided only by teachers who are provided with computer equipment and Internet access. At the same time, 3.12% of the surveyed (GSEI) leaders stated that their school did not switch to remote work mode.

Under quarantine, educational institutions use different modes of distance learning, programs and digital services. GSEI leaders noted that online learning is mainly used for distance work. The most effective are services with the ability to assess the level of assimilation of the material – they are used by 44.88%, without the possibility of evaluation – 20.27%. Asynchronous learning with the ability to assess the level of assimilation of the material is carried out by 20.55% of GSEI.

According to the report, the issue of establishing effective interaction with participants in the educational process is identified as one of the most difficult in the implementation of distance learning along with technical support, methodological training and organizational issues (Pavlik and McIntosh, 2016).

As noted in the “Global Guide 2020”, in the USA Facebook, Instagram, and Linkedln are the dominant social media platforms for education, where available. Twitter and YouTube are also popular social platforms for education. There were used virtual meeting platforms such as Zoom and Google Meet to expand and enhance outreach (EducationUSA, 2020).

We analysed the results of Project Tomorrow, an education nonprofit that runs the on-going Speak Up Research Project (Evans, 2020). The latest data gives responses from 110,467 K-12 students, 11,731 teachers and librarians, 1,128 school and district level administrators, 11,749 parents and 1,532 community members collected between March 16 2020 and June 30, 2020 (tomorrow.org, 2020).

The situation in which schools found themselves in connection with the pandemic, opened new opportunities for more students to regularly communicate with their teachers using email. Email communications with teachers and students in middle school, for example, increased 33% during school closures: The percentage of students in grades 3–5 who regularly email their teachers also increased from 8% to 16%. Over three-quarters of students in grades 6–12 (77%) report that personal emails are now a standard mode of communications with their teachers. Students are reporting that this new communications avenue provided more efficient and effective ways for them to get feedback from their teachers and to help them solve learning challenges with just-in-time support.

The new environment has also accelerated the adoption of text messaging between students and teachers as a communications modality. In 2015, only 14% of teachers said that they were using texting to communicate with students. Though teachers regularly report using text messages and other forms of social media to communicate with colleagues (57%) and even parents (28%), their adoption of this tool to communicate directly with students, either individually or as a class, has not increased in the past five years.

Relative to teacher communications, middle school students are united in their preference for three types of digital tools, personal emails (56%), text messages (55%) and auto phone messages (49%).

The sudden shift to digital learning as a result of the pandemic-induced school closures required many school and district leaders to think differently about the purpose of school, new modalities for instruction, and how to effectively harness a wide range of digital tools to support learning continuity. In some cases, administrators relaxed district rules about the use of personal devices, mobile apps and social media accounts to help facilitate efficiency and effectiveness in this unprecedented time. For example, while most districts did not encourage teachers to text message with students prior to the school closures, the use of texting increased significantly during the school closure period as both students and teachers (as well as parents) found the usage to be highly effective. Given both the value of those enhanced communications channels, and the continued uncertainty in school formats during pandemic, it is most likely that more digital tools, even including new social media platforms, will emerge to support student-teacher communications.

District technology leaders (54%) say they understand the importance of putting in place safeguards to protect student data when instituting a new digital initiative or adopting new technologies to support instruction. However, only 17% of school districts are currently using a risk dashboard to identify students in trouble or in need of adult intervention based upon their communications messages over the school network.

This issue of communications over the school or district network versus a student or teacher using a personal smartphone and their own data plan to transmit messages is also an important consideration. Efficiency of communications was a chief concern during the school closures, and thus as documented many students and teachers gravitated easily to their own personal accounts to help facilitate those interactions. However, 52% of district technology leaders say they encourage teachers and students not to mix personal and school accounts and applications in their communications.

The school principals say that they would like new teachers to learn how to effectively leverage social media tools for student engagement and communications within their teacher preparation programs. With a new mindset about the value of technology to support enhanced student-teacher communications, the opportunity for effectively leveraging new tools in the classroom, whether that is an online classroom facilitated through Google or the physics lab on the second floor, appears promising.

For the dissemination of school information American school principals use such social media: 58% – Instagram, 58% – YouTube videos, 53% – Snapchat, 58% – Twitter, 47% – Text messages (tomorrow.org, 2020).

In another survey "2019 Social Media Trends in Education Report" (classintercom.com, 2019) developed by Class Intercom we observe that 95% of schools use social media to communicate during the pandemic. 85% of schools report using photos to share the virtual, in-person, and hybrid learning taking place. Another 79% use video to share what is happening in their schools and district. 37% of schools are allowing students to contribute to their social content. 40% of districts have up to 10 users with administrator access to social accounts. Nearly 20% of schools are investing in paid social.

But school and district leaders need to be cognizant of protecting student data and student safety when using these new online tools for communications, with peers and teachers. Additionally, as these tools become more pervasive, districts will want to fully understand their legal obligations in terms of retaining messages and their responsibility and accountability for staff usage of these tools.

5 WAYS TO PREPARE SCHOOL LEADERS FOR USING OF SOCIAL MEDIA IN SCHOOL MANAGEMENT IN A PANDEMIC

According to a survey conducted by the State Education Inspectorate of Ukraine, the lack of support and understanding of the situation from parents is recognized as a problem by 28.2% of respondents from 3.9 thousand school principals (Pavlik and McIntosh, 2016).

The things that can contribute to this:

1. **Professional training of school leaders in the master's degree "Management of the educational institution" and "Educational Administration"**

Training of future managers of educational institutions is carried out according to the educational-professional program "Management of educational institution" specialty 073 "Management" in the field of knowledge 07 "Management and Administration", approved by the Academic Council of the University of Educational Management of the NAES of Ukraine taking into account the Standard of Higher Education for the second (master's) level of higher education(MON, 2019).

The purpose of this program is to train new generation of education managers who are able to identify and solve complex specialized problems and practical problems in the management of educational institutions, their units, subsystems to meet the educational needs of the state, society, educational institutions and students.

Normative content of training of higher education, formulated in terms of learning outcomes in higher education in the field 073 "Management" for the second (master's) level of higher education specified in the disciplines of general training and free choice of curriculum for candidates educational program "Management of educational institution" of the second (master's) level of higher education (MON, 2019).

In the context of our study, the educational program provides for the acquisition of general competencies, including: the ability to think abstractly, analyze, synthesize and establish relationships between phenomena and processes (general competence 1); ability to communicate with representatives of various professional groups and in the international context (general competence 3); skills of using information and communication technologies for search, processing, analysis of information from various sources and decision making (general competence 4) and acquisition of professional (special-professional) competencies of the specialty (professional competence 6), including the ability to create and organize effective communications in the management process) (Makhynia, 2018).

In the United States, future school principals are trained in the Master in Educational Administration program, because in order to become a high school principal, you must have a master's degree in school administration and become certified as a school administrator or principal. In the learning process, future education managers trains educators to become school principals and administrators, with a focus on serving diverse educational communities and fostering student achievement (thebestschools.org, 2021). A school administrator or principal must be certified. For example, The Principals' Training Center for Practicing and Aspiring Principals in International Schools offers a course "Technology Leadership", in the process of studying which students should know how does a principal juggle the demands of digital communication, social media and digital environments in a school setting, how can digital tools and environments be utilized to create sustainable and vibrant learning communities etc (thebestschools.org, 2021).

2. **Introduction of school principals with the topics and opportunities of massive open online courses (MOOC)**

The opportunity to study at a convenient time, free access to the latest information, teaching materials, modern technologies and practical cases, the opportunity to learn from the best universities and teachers in the world have led to the widespread popularity of the MOOC among its students.

Among the proposed MOOC, we have selected courses in three areas, which, in our opinion, contribute to the readiness of school principals in the United States and Ukraine to using social media in school management. These include media literacy and critical thinking; cybersecurity and establishing effective online communications.

Critical thinking and the educational process built on its foundations have become the basis of educational reforms in the world's leading countries over the last 10 years (Abdula et al., 2020; Konoval et al., 2021; Prykhodkina, 2020). The World Economic Forum in Davos regularly lists the relevant skills needed for a successful career. In recent years, critical thinking has risen in the ranking of these skills from the 4th place (skills for 2015) to the 2nd place (skills that will be important in 2020). The ability to think critically ensures scientific, technological and social progress and is the key to democracy, and education plays a key role in its development. Critical thinking provides independent and responsible action, as well as self-improvement (table 3).

Information and its timely access provides the maximum competitive advantages. However, it is equally important to be able to protect this information. Our MOOC content analysis showed a number of courses aimed at learning exactly how and why a person can be attacked in the information space, as well as how to improve their own information security, which will further develop an effective program to protect personal information resources (table 4).

During the pandemic conditions, the issues of fast and consistent information reporting about the peculiarities of the educational process by means of various media became especially relevant. The principals have to be ready to convey information accurately, to focus on the main thing, to focus on the simplicity and accessibility of messages through those social media that are most adequate to the audience. A number of MOOCs are dedicated to this topic (table 5).

3. **Certification training of school principals according to the relevant programs**

In particular, a number of media literacy training programs developed by the Academy of Ukrainian Press are actively implemented by the Institutes of Professional Development of Teachers, including school principals (www.aup.com.ua, 2020).

In addition, 11 special courses for training school principals at working in the digital society, aimed at establishing effective online and Cybersecurity communications, have been developed since the beginning of the pandemic by the Ukrainian Open University of Postgraduate Education (uvu.org.ua, 2020).

Duration of such courses 1 ECTS credit / 30 hours. Based on the results of the training, a certificate is issued under the license of the University of Education Management.

In the United States, Media Management and Leadership is offered in higher education institutions. The course is designed for 3 ECTS credits (90 hours). This course aims to give students a survey of some of the latest management and leadership theories, including those encouraging a new sense of social responsibility. It also gives students the opportunity to apply these theories to a number of different competitive, structural, motivational, strategic, and organizational issues in the media world, by writing original case studies and solving problems in existing case studies (The New School, 2020).

6 CONCLUSIONS

So, in 2019 the educational opportunities of social media among Ukrainian specialists are very underestimated. The value of social media as an instrument of the educational process is undeservedly belittled. Many educators treat them with neglect and skepticism, considering social media exclusively as an entertaining resource. Using of social media for educational purposes is perceived by American students,

Table 3: MOOC, represented at English and Ukrainian platforms, aimed at developing media literacy and critical thinking for school principals.

The results of monitoring of Ukraine	**The results of monitoring of the USA**
(1) "Critical Thinking for Educators" on the platform Prometheus	(1) Media LIT: Overcoming Information Overload (Arizona State University) on edX
(2)"Educational tools of critical thinking" on the platform Prometheus	(2) Sorting Truth From Fiction: Civic Online Reasoning (Massachusetts Institute of Technology) on edX
(3) "The science of everyday thinking" on the platform Prometheus	(3) Making Sense of News (University of Hong Kong) on edX
(4) "English for media literacy" on the platform Prometheus	(4) Fake News, Facts, and Alternative Facts (The University of Michigan) on edX
(5)"Media literacy" on the platform Prometheus	(5) Fake News (Davidson College) on edX
(6) "Media literacy: practical skills" on the platform Prometheus	(6) Critical Thinking: Fundamentals of Good Reasoning (IsraelX) on edX
(7) "Factcheck: trust-check" on the platform EdEra	(7) Problem Solving and Critical Thinking Skills (Fullbridge) on edX
(8) "Internet Verification" by VUM online	(8) Global Media, War, and Technology (The University of Queensland) on edX
(9) "Media Literacy for Citizens" from IREX in partnership with the Academy of Ukrainian Press and StopFake	(9) Understanding Media: Introduction to Media Literacy and Representation (The University of Newcastle Australia) on FutureLearn
(10) "News Literacy" by Media Detector	(10) Disinformation, Misinformation, and Fake News Teach-Out (University of Michigan) on FutureLearn
(11) "Very Verified: an online media literacy course" on the platform EdEra	(11) Developing Literacy: A Journey from Still Image to Film (Into Film) on FutureLearn
	(12) Making Sense of Data in the Media (The University of Sheffield) on FutureLearn
	(13) Making Sense of the News: News Literacy Lessons for Digital Citizens by Coursera

Table 4: MOOC, represented on English and Ukrainian platforms, aimed at the development of Cybersecurity for school principals.

The results of monitoring of Ukraine	**The results of monitoring of the USA**
(1) "Digital Security and Online Communications" by VUM online	(1) Introduction to Cybersecurity (University of Washington) on edX
(2) "Information security in the digital world" by VUM online	(2) Information Security – Introduction to Information Security (New York University) on edX
(3) "Media literacy for educators" by Prometheus	(3) Introduction to Cyber Security (The Open University)

teachers, researchers as self-evident and inalienable function. The American didactic experience reveals that social media can be successfully used to arrange the work of the teaching staff and students, hold individual and collective consultations enhancing intellectual and creative potential of students.

In 2020, the pandemic became a catalyst for rapid change in the use of social media in educational process at schools. Heads of education in Ukraine and in the United States almost simultaneously found themselves in the same conditions: the management of secondary education, the organization of training, the transfer of educational content using online educational platforms, social media. We analyzed the data reports "Global Guide 2020", "90 days that changed K-12 teaching & learning: strengthening the bonds of communications", "2019 Social Media Trends in Education Report", "Digital learning during the pandemic: Emerging Evidence of an Education Transformation" and the Ukrainian State Education Quality Service for 2020. The results showed that in Ukraine as well as in the United States, social me-

Table 5: MOOC, represented on English and Ukrainian platforms, aimed at establishing effective online communication among school principals.

The results of monitoring of Ukraine	The results of monitoring of the USA
(1) "Communication tools for reputation building" by Prometheus	(1) From Digital Technologies to Social Media (Curtin University) on edX
(2) "Digital communications in the global space" by Prometheus	(2) Understanding Media: Introduction to Media Literacy and Representation (The University of Newcastle Australia) on FutureLearn
(3) "How to understand social networks. Course for journalists" by VUM online	(3) Developing Literacy: A Journey from Still Image to Film (Into Film) on FutureLearn
(4)"Effective communications for educational managers" by EdEra	(4) Respecting Our Differences Online (Samsung) on FutureLearn
(5) "Media literacy for educators" by Prometheus	(5) Smart Media Communication by XuetangX
	(6) Ethical Social Media by COURSERA

dia became the most important communication tool during the pandemic. In the United States, there is a greater variety of types of social media for use in school education. The reason is that the United States is a leading country in the field of digitalization of the economy and the creation of innovative learning technologies. But the most popular social media in school management is Instagram, YouTube videos, Facebook, Snapchat, Twitter, Text messages (WhatsApp).

As our research shows, despite a wide range of available technologies, the United States is experiencing significant difficulties in organizing online education. In order to teach how to build effective communications for education managers, how to develop their media literacy, critical thinking, and knowledge in the field of cybersecurity, a lot of massive online courses have been created in the United States (edX, Udemy, FutureLearn, XuetangX platforms). With the support of international organizations (UNICEF, IREX, DW) such courses have also been created in Ukraine (platforms EdEra, Prometheus, VUM online).

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Methodology of M. Montessori as the Basis of Early Formation of STEM Skills of Pupils

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Keywords: Constructivism in Education, Innovative Pedagogical Technologies, Montessori, STEM, STREAM, STEAM, Web Mapping.

Abstract: The ideas of the constructivist paradigm of education continue to develop in the XXI century. In this context, the STEM approach is being implemented very dynamically for the formation of curricula of formal and non-formal education institutions. At the same time, M. Montessori pedagogy educational centers remain popular in Ukraine. Based on the use of web mapping service Google Maps, the authors searched, identified and quantitatively analyzed the distribution of educational institutions in Ukraine that use the STEM-STEAM-STREAM approach and methodological tools of M. Montessori pedagogy. The results of data processing are presented in the form of author's maps and diagrams, which indicate the number of Montessori pedagogy centers and STEM-STEAM-STREAM training centers for each region. Based on the data of the official websites of educational institutions, an analysis of the content and organization of some Montessori centers in Ukraine was carried out that is demonstrated by means of examples. To obtain a conclusion about the state of development of pedagogical technologies the method of Gartner Hype Cycle is used. Comparison of the principles of pedagogy M. Montessori and STEM approach to education reveals many common didactic features based on the ideas of constructivism in education. In particular, we want to note the features of active interaction of subjects of the educational process, the development of curiosity, change of the teacher functions.

1 INTRODUCTION

The requirement of society to form the ability and readiness of the individual for successful socialization to withstand the challenges of the XXI century determines the development of the variable education in Ukraine, which is demonstrated in the reform of education at all levels. This is supported by the autonomy of educational institutions (Verkhovna Rada of Ukraine, 2017) and, as a consequence, the development of educational services based on a wide range of innovative programs and methods. The STEM approach is gaining popularity in educational environment (Kramarenko et al., 2020); it is streamlined by the support of the state (IMZO, 2016).

The pedagogical system of M. Montessori (Dychkivska and Ponymanska, 2009) is acknowledged as a classic innovative technology of education for children from the very young age, its relevance is confirmed by the functioning of numerous pedagogical centers. Note that the Montessori approach meets all the principles of humanitarian pedagogy: the child's personality with all individuality, similarity and difference from other children is in the center of the educational process (Mavric, 2020).

On the other hand, the pedagogical problem of early detection and development of engineering abilities is especially relevant in the era of rapid development of tools and technologies. In this context, significant help is expected from innovative learning technologies, which include the STEM approach in education (Krutiy and Hrytsyshyna, 2016; Marshall, 2017).

The development of the educational centers in

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Ukraine is result of the society and the state demand. Is M. Montessori's pedagogical technology relevant for domestic educational institutions in comparison with the STEM-STEAM-STREAM approach? What unites these different pedagogical systems? Up-to-date data for the answers can be obtained through the use of web mapping service tools Google Maps.

2 ANALYSIS OF RECENT PUBLICATIONS AND RESEARCH

Almost 120 years of implementation of Montessori pedagogical ideas around the world are reflected in numerous scientific works (Smith, 1911; Allen, 1913; Paton, 1915; Levy and Bartelme, 1927; Stern, 1930; Claremont, 1952; Montessori, 1961; Drenckhahn, 1961; Beck, 1961; Stendler, 1965; Denny, 1965; Argy, 1965; Roeper, 1966; Denny, 1966; Gitter, 1967b,a, 1970; Morra, 1967; Cohen, 1968; Edgington, 1970; Edwards, 2002; Lopata et al., 2005; Rathunde and Csikszentmihalyi, 2005; Lillard and Else-Quest, 2006; Lillard, 2012; Lillard et al., 2017; Dohrmann et al., 2007; Beatty, 2011; Whitesgarver and Cossentino, 2008; Dodd-Nufrio, 2011). The ideas also prove the relevance in the XXI century: from the earliest works on the introduction of Montessori methods as a didactic tool for speech development of preschool children and teaching them to read and write (Dychkivska and Ponymanska, 2009), through the study of sensory and motor skills, game techniques to stimulate communicative activity of preschoolers as a basis of speech skills. The need for integrative techniques based on the STREAM approach is revealed in the work of Krutiy and Hrytsyshyna (Krutiy and Hrytsyshyna, 2016). Mavric (Mavric, 2020) emphasizes on the importance of pedagogical ideas of M. Montessori for educational systems of the XXI century exploring the didactic aspects of personalized instructions; in particular, she points to the dual role of the teacher as "knowledge facilitator who offers advice and is a training specialist" at the same time. The same work shows the best academic results of the pupils comparatively to other public or private primary schools, in particular, in mathematics and physics (Mavric, 2020). Essential for the Montessori teaching method is the dynamic interaction of the triad "child, teacher, environment (prepared situations)". Remarkable is comprehension of the Montessori Method proposed by Marshall (Marshall, 2017) in the context of two important aspects: educational materials and the way in which the teacher and the design of the prepared environment promote independent interaction of children with these materials. It also draws attention to confirmed over time significant adaptability of the method.

On the other hand, socio-economic processes and challenges of the XXI century determine the problem of high-quality technical and technological teaching of the younger generation: the STEM abbreviation is actively used in all spheres of our life to describe processes in the agro-industrial complex, medicine, energy, robotics, IT market, transport, industry, and, above all, in education.

The abbreviation STEAM (Science, Technology, Engineering, Arts / All, and Mathematics) is widely used nowadays to indicate that the technology is used to study not only technical sciences but also arty disciplines, for example, industrial aesthetics, industrial design, 3D modeling, architecture, cinema (Stetsenko, 2016). Another important area is the STREAM approach in education (Science, Technology, Reading + WRiting, Engineering, Arts and Mathematics) aimed at early education of the culture of engineering thinking and the formation of pupils' skills in technology, science, reading and writing, engineering , art and mathematics. This approach is intended to form critical thinking of preschool and primary school children; according to the age characteristics, mainly emotions are used to motivate the children to learn (Krutiy and Hrytsyshyna, 2016). In general, the key aim of STEM-STEAM-STREAM approaches to curriculum development is to expand the consciousness of participants of the educational process, help to actively respond to changes in reality but not "direct transfer" of knowledge (IMZO, 2016).

At the same time, according to Lapon (Lapon, 2020), the methods based on the ideas of M. Montessori are focused on the education of respect for learning, encouraging the child's curiosity through realistic experience, creativity and self-understanding.

In order to determine the probable "points of contact" of the STEM / STREAM approach and M. Montessori's methodology, we will consider their peculiarities of educational process. According to the description of Dychkivska and Ponymanska (Dychkivska and Ponymanska, 2009), M. Montessori's method is aimed at studying five aspects of life: practical life skills, sensory, mathematics, speech development (reading and writing), space education (history, time, nature). The child's independence and freedom is at the center. Possibility for pupils to make mistakes, analyze them, seek help from more experienced pupils or the teacher. This technique effectively encourages the development of critical thinking and forms the skills of finding creative approaches to problems solving (Lapon, 2020).

A long time of research and practical implementation of methods based on the ideas of M. Montessori showed that it is most effective at the early stages of child development. This leads to the assumption about its similarity with STEM and STREAM approaches aimed at early career guidance of new generations, deepening skills, creating opportunities for research work, conducting scientific and technical activities and more.

3 RESEARCH METHODS

The *aim* of the article is to clarify the roots of common features of Montessori pedagogy and teaching methods based on the STEM-STEAM-STREAM approach. Subsequent aim is a comparison of their applicability in the educational space of Ukraine based on data web mapping service Google Maps.

To compare educational technologies in Montessori schools and STEM-STEAM-STREAM educational centers, the analysis of scientific literature and data from open sources is used, which demonstrate the current practical aspects of the implementation of these methods in Ukraine.

An important indicator of the activity of the use of the above mentioned innovative learning technologies is the public demand for running of the related centers of education. For this purpose, the search and identification by means of the web mapping service of the Google Maps system was used. An example of the result of such a search is shown in figure 1; it demonstrates a screenshot of the Google Maps application for a search inquiry for the keywords "Zhytomyr Montessori School", "Zhytomyr Montessori Kindergarten", "Montessori Zhytomyr".

4 RESULTS AND DISCUSSIONS

Comparisons of the system of free education of M. Montessori and STREAM-approach in education reveal many common features, in particular:

- focus on the formation of certain skills, their conjunction with knowledge of the world around, self-awareness and own role in society;
- the possibility of effective implementation of these technologies at all stages of child development;
- joint activities of teacher and pupil aimed at solving practically significant problems;
- use of acquired skills in everyday life with an approximation for future professional activity;
- promoting communication and team spirit;
- development of interest to certain actions, subjects, and the process of new knowledge obtaining;
- introduction of creative and innovative approaches in the educational process;
- preparing the student for future successful socialization and the formation of lifelong learning skills.

4.1 The Paradigm of Constructivism in Education as the Basis of Similarity of Methods

The similarity of these pedagogical technologies, the implementation of which separates 100 years, should be evaluated as a practical embodiment of the constructivist paradigm of education; its origins are in the interdisciplinary field of philosophy, psychology, sociology and education (Bada, 2015). Note that the development of constructivism as an evolutionary epistemology began with the works of von Glasersfeld (von Glasersfeld, 1995), Piaget (Piaget, 1980), Vygotsky (Vygotsky, 1962) and others. The main idea of this philosophical trend in the context of learning and teaching concerns the mutual influence of participants of the educational process and learning environment (Komar, 2006): knowledge is formed through active social interaction and communication where shared experience is developed; learner builds during the learning process a new understanding and concept of the learning environment.

The important role of the paradigm of constructivism for the functioning of the digital educational environment is pointed out by Tchoshanov (Tchoshanov, 2013). Lee and Lin (Lee and Lin, 2009) demonstrate the paradigm application in the context of distance and blended learning emphasizing that the aim of any methodological system is not transfer of knowledge in a ready form but creation of pedagogical conditions for successful self-development of learners according to their own educational trajectory. In addition, the paradigm of constructivism is characterized by personal orientation and respect for students, promoting independence, teamwork, attention to the formation and development of skills to solve problems of different sources (Dagar and Yadav, 2016), i.e. flexible skills or skills of the XXI century.

Note that STEM education, as well as the method of M. Montessori, in addition to scientific and tech-

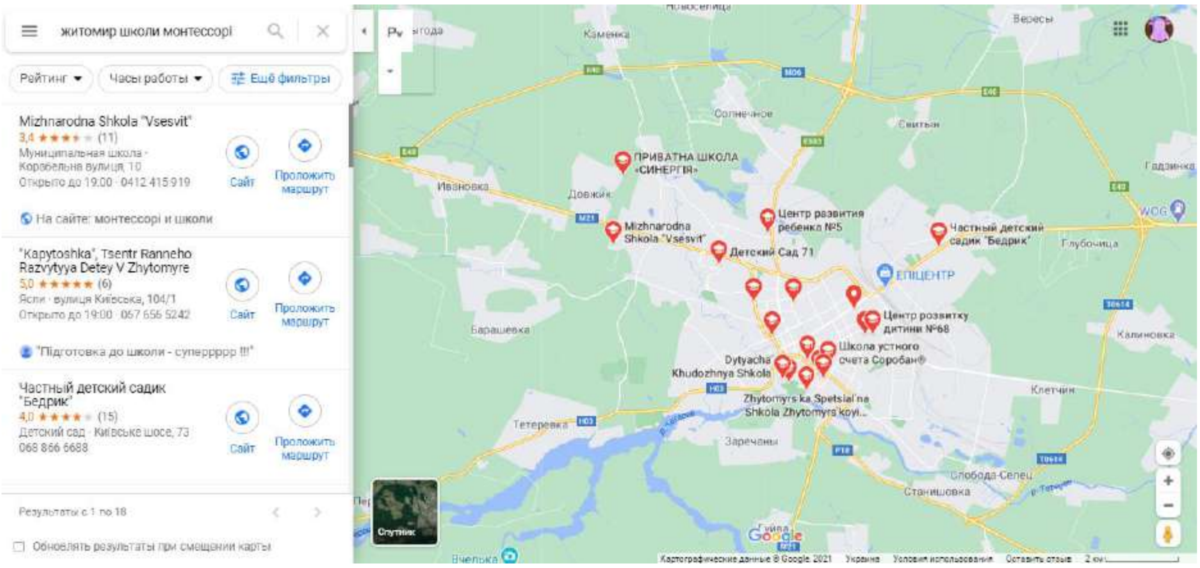

Figure 1: Search for Montessori centers in the city of Zhytomyr using the search and mapping service Google Maps.

nological components of education, focused on creative development of personality, critical thinking, independence in decision-making, empathy for society and other characteristics that are key skills of the XXI century.

Another important feature characteristic of the STEM / STREAM approach in teaching and methods of M. Montessori is the use of toys (from simple to technically and technologically oriented) and game techniques to acquire new knowledge and skills (Marshall, 2017). They teach to master the laws of nature, the idea of how our world works and how to explore the surrounding space, first of all, by improvised means. In general, the gamification of the educational process is one of the driving forces of these learning technologies (Buzko et al., 2018; Fedorenko et al., 2021).

4.2 Analysis of Web Mapping Data About Montessori Centers in Ukraine

The compliance of educational service centers was checked by researching the content of the Institutions site. Based on a detailed analysis of all the results provided by the system for each of the inquiries and the separation of those that do not use the principles of the pedagogical system of M. Montessori, a map showing all institutions of formal and non-formal education of public and private property that fully or partially declare the use of these principles of learning was drawn up (figure 2).

As can be seen in figure 2, the largest number of Montessori centers operating in Ukraine is concentrated in the capital and western regions (Lviv and Volyn), the smallest part is determined in the eastern regions of the country. The study showed that there are 60 centers in the central regions, 24 in the eastern regions, 75 in the western regions, 45 in the northern regions, and 47 in the southern regions. The significant number of Montessori centers in Kharkiv (14) and Cherkasy (12) regions is obviously due to the presence of powerful centers in these regions such as pedagogical universities. This method is the least popular in Luhansk, Zakarpattia and Khmelnytsky regions.

In order to identify the features of modern educational environments of M. Montessori schools, we analyzed the online content of the proposals of such educational centers, which are highly valued by network users (one example from the relevant region of Ukraine). Let us briefly consider the educational proposals of some of them. Thus, the Center for Child Development mini-kindergarten "Lviv Montessori School" implements a program for children 6–12 years old and is a full-time educational institution where, in addition to standard subjects, children study supplementary subjects: physics, chemistry, worldview, art of photography, painting, choreography, piano, and have thematic excursions (Facebook, 2021b). An important feature of the pedagogical methodology of this school, as stated on the website of this educational institution, is the use of active self-assessment by pupils, cooperation (children of different ages spend a significant amount of time together, they have to work together to solve differ-

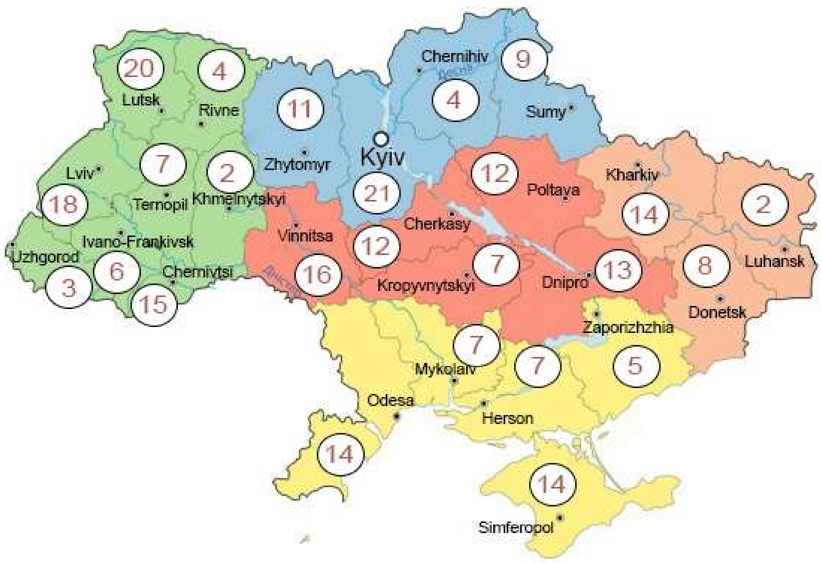

Figure 2: Distribution of Montessori pedagogy centers in Ukraine.

ent problems). Based on this, pupils do not get ready for the sake of assessments, but because they are interested in learning and exploring the world around them.

Another example of effective implementation of Montessori's ideas in practice is the program of the Center for Child Development "Anthill" in Ternopil, which combines traditional forms and methods of working with younger pupils and the so-called "events" in a prepared environment where pupils can choose activities, interact with children of other ages, independently study the objects of this environment (Facebook, 2021a).

Montessori New Age School has a "Montessori class", which is equipped with a complete set of Montessori materials for comprehensive and harmonious development of children and is divided, like the STEM learning space, into several functional areas; some of them are designed to develop a variety of practical skills, improve motor skills and coordination. Also, there are materials for the development of sensory sensations, speech, mathematical abilities, as well as acquaintance with the world around (Montessori New Age School, 2021). It is also emphasized the importance of the role of the teacher: "conducts constant observation and ... knows at what stage of development each child is, what occupation should be offered to him for a further step forward". Attention is drawn to the significance of the mixed-age groups of Montessori New Age School, which creates optimal conditions for the social upbringing of children on the principle of a large family and folk pedagogy. The mission of the New Age School is to create a special educational environment in which children learn through their own experiences and feelings.

The study showed that the activities of Montessori pedagogy centers in Ukraine are mainly focused on the education and training of preschool children. Some example is the Montessori World full cycle school in Kharkiv (montessoriya.kh.ua, 2021), which uses an interdisciplinary approach to designing courses and curriculum subjects with a special emphasis on preparing children through practical activities for real life. Among the training courses are the following: writing and project activities (for example, spelling is studied on topics that interest children: human structure, animal habitat, rivers or volcanoes of different continents); publication of a school newspaper studies to keep the audience's attention, present the project, ask questions, gain experience in public speaking. Due to special manuals and didactic materials, children can divide the whole into parts, solve geometric problems and prove theorems. The course "Physics, Chemistry, Astronomy" is aimed primarily at experimental activities, creating projects that are the foundation for in-depth study of these sciences at high school, the course "History and Geography" uses elements of museum pedagogy. Communicating with teachers of Karazin University in classes on "Botany and Zoology", children observe plants and insects, care for animals in their own "living space" and grow plants. During classes "Financial knowledge and management" pupils learn to put financial and economic aims, manage finances and plan a budget, in particular, through outings, excursions, teamwork at fairs, holidays, purchasing products. The course "Art and Painting" includes regular master classes on felting wool, origami, etc. Besides, it is aimed at developing practical life skills and social responsibility: children develop menus, prepare dinners, set the table, wash dishes, clean the classrooms, clean up the forest of rubbish, sort garbage, and hand over waste paper. In this Montessori environment, pupils participate individually and in groups. Classes are divided into thematic areas: mathematics, languages, geography, history, biology, space; there is a laboratory. Due to this the learning approach is realized: teach the child to think, find solutions, make discoveries, search for information and be able to apply it when needed.

It should be noted that most educational institutions that use Montessori's ideas are private, such as the Clever Kids Elementary School in Kyiv. In addition to the annual curriculum in accordance with the standard, for each child, taking into account the gifts and flaws of the pupil, his abilities, main interests, age goals, phase of character development, and level of ability to control emotions and interact with the team is worked out a personalized curriculum (Clever Kids, 2021). Particular attention is paid to the formation of project activities skills that promote children's interest in research, skills of planning and organizing their working time, critical, analytical and abstract thinking skills, and teamwork. Among the pedagogical tasks of the Clever Kids are also assistance in the pupil potential development, development of independence and self-sufficiency of thinking, respect and empathy for others, responsibility and leadership qualities. There are created conditions for the development of children based on their individual step and biological rhythm, formation of skills of independent work, promoting the initiative in the choice of materials, stimulating the development of self-discipline skills, cooperation with parents and more. Emphasis is placed on the importance of the activities of teachers, whose mission is to find ways to inspire children to learn. Such support allows children, first of all, to gain confidence and strive to perform tasks constantly without fear of failure. Emphasis is placed on the gradual complication of tasks, which creates opportunities to go through the process of aim setting and experience of personal victory.

Thus, the study of information about Montessori education centers in Ukraine showed that the modern interpretation of pedagogical postulates for socialization and upbringing of the child is indisputable and can resolve the contradictions associated with the implementation in practice of the basic requirements for the modern educational process: individualization, reliance on sensitive periods, the priority of personal independence, the ability to make choices and respect the choices of others, freedom and discipline in different age communication, etc.

Our study showed that there are more than 250 educational institutions in Ukraine that use the methods and principles of teaching Maria Montessori. For comparison, in Germany there are about 1000 preschool institutions and 400 schools operating on the basis of Montessori pedagogy: gymnasiums are 40 percent, general schools – 25%, primary – 20% and real schools – 15% (Priboschek, 2020). Thus, the ideas and pedagogical system of M. Montessori remain relevant in the education of the XXI century.

4.3 Analysis of Web Mapping Data About STEM-STEAM-STREAM Centers in Ukraine

For comparison, a map of the development of STEM-STEAM-STREAM centers was created in a similar way (figure 3).

Our research showed that there are more than 190 teaching centers in Ukraine that use STEM-STEAM-STREAM technologies. 45 STEM centers are functioning in the central regions, 9 centers in the east regions, 62 centers in the western regions, 41 centers in the northern regions, 30 centers in the southern regions. This is due to the fact that STEM education in Ukraine is only gaining popularity, and their largest number we have only in large cities (Kiev, Lviv). The smallest number of STEM institutions is located in the eastern and southwestern regions.

The obtained data on the development of educational centers in Ukraine based on the pedagogy of M. Montessori and STEM-STEAM-STREAM centers are presented in the form of diagrams (figures 4, 5).

The development of Montessori pedagogy, which is presented on figure 4, shows that the Montessori concept is widely known in Ukraine. Nonetheless, since this practice is used only by private schools and kindergartens, it is not available for many children and its percentage is small in some regions. The largest centers and networks of STEM centers and Montessori schools are located in Kyiv.

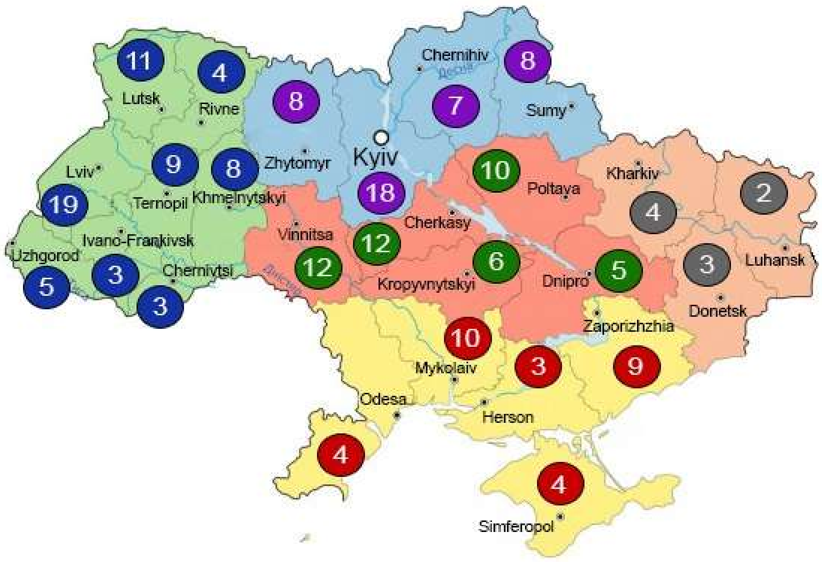

Figure 3: STEM-STEAM-STREAM centers in Ukraine.

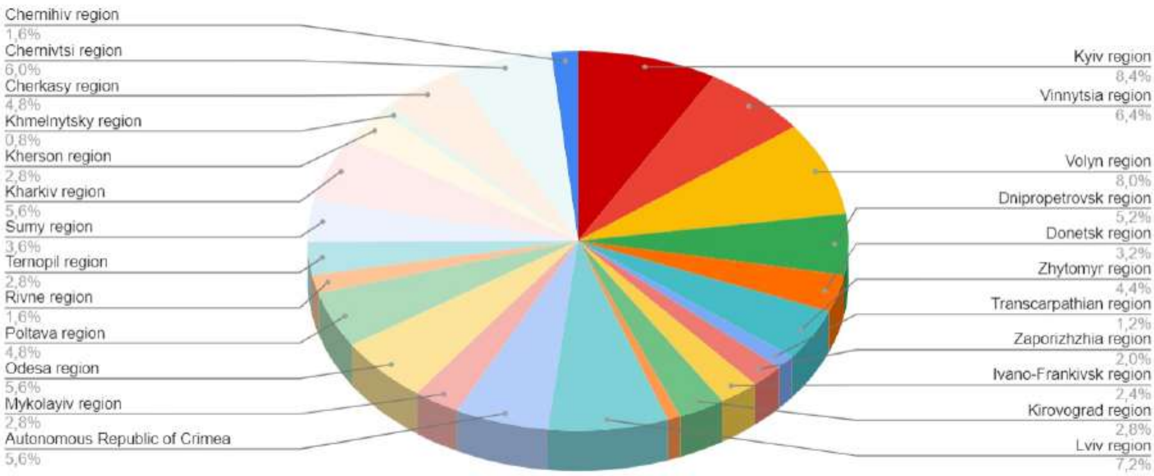

Figure 4: Quantitative distribution of Montessori pedagogy centers in Ukraine.

5 CONCLUSIONS

The analysis of the peculiarities of M. Montessori methodology and STEM approach in education revealed their common origins from the constructivist philosophy in education. The relevance of these ways in formal and non-formal education in Ukraine is demonstrated by investigation using web mapping service Google Maps. It creates grounds for the conclusion about the possibility of their harmonious complement: organizational and pedagogical condition of their operation is creation a special learning environment capable to adaptation to personal ideals and cognitive needs of participants of the educational process favorable in the context of the development of soft skills (Sultanova et al., 2021; Varava et al., 2021).

We have noted supplementary didactic features of Montessori technology characteristic for STEM technologies:

- focus on the formation of a permanent interest to the processes and phenomena in the world, the development of curiosity based on research using the steps characteristic to the scientific method and the process of engineering design;

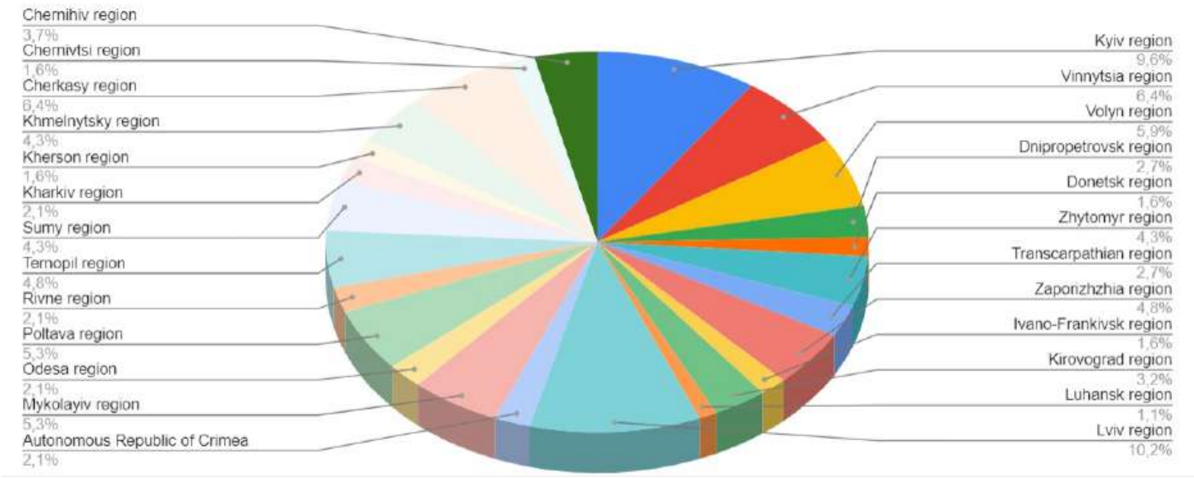

Figure 5: Quantitative distribution of STEM-STEAM-STREAM centers in Ukraine.

- changing the role of the teacher, shifting the emphasis to motivation for productive activities, stimulating development, creating a pedagogical ecosystem of formation the scientific picture of the world in the minds of students and, at the same time, key skills of the XXI century.

A comparison of the created maps provides grounds for concluding that the Montessori methodological system has adapted to the rapid development of machinery and technology in the XXI century; the popularity of STEM educational centers is growing rapidly in Ukraine (almost 200 new centers in 10 years). The use of the Gartner Hype Cycle method to describe this process (Gartner, 2019) suggests that Montessori pedagogy is now on a "plateau of productivity" and that STEM approaches in education are in a state of active implementation, which corresponds to "innovation trigger" and approach the "peak of inflated expectations".

STEM technologies of teaching and pedagogical ideas of M. Montessori harmoniously complement each other, especially in the context of forming the ability to successful self-development based on maintaining the relationship between the child and the developmental subject-spatial environment (M. Montessori), which at the present time can be digital (STEM).

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The Role of Media Literacy in the Conditions of Information Risks: Specifics of Educational Communicative Experience 2020 Regarding the Freedom of Media Communication and Social Isolation

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Abstract: In the era of the information society, with the experience of social isolation during the pandemic, each of us is permanently influenced by a flurry of information that varies in content, quality, verifiability, motivational orientation. Therefore, the primary task is to create conditions for information security. One approach to solving this problem is media literacy education. This article discusses strategies of the introduction of media education in international organizations, analyzes the specifics of media education and media literacy in various aspects and examines the role of critical thinking in countering information aggression as an intensification of risks and dangers in terms of establishing norms of social distance for prevention of epidemiological threats.

1 INTRODUCTION

Nowadays, it would not be an exaggeration to say that every research development, scientific reflection on modern social and information processes are necessarily caused, to varying degrees, by the experience that is transforming global reality that humanity gained in 2020. Its context is still unfolding. The COVID-19 pandemic has not only changed the semantic vector of political, economic, legal and other preferences owing to its direct physical threat to human's life and health (Tkachuk et al., 2021; Velykodna, 2021). Primarily, it has become a globally new dimension, a real leap into the information society era. Our previous knowledge of this new world of digital reality in anthropological and socio-cultural aspects turned out to be nothing more than an "airbag" that worked during the transition time to a society whose global and local bonds are information networks. In fact, a person's life in the fullness of social contacts, a direct presence in various practices of routine life, dispersed on the paths of its multimedia activity. Digital technologies, information and communication resource of continuity of social interaction, have become a real salvation. At the same time, today, it is worth thinking about unexpected and unpredictable threats of a communicative, socio-cultural nature we have encountered.

The topicality of this problem is associated with the essential characteristics of the information society itself: the determining, governing role of information in relation to various segments of social life. Information flows structurize and direct social activity primarily through a multimedia communication system of interaction. Thus, each of us is permanently influenced by a flurry of information, which differs in content, quality, verifiability, motivational orientation. As Luhmann (Luhmann, 1992) aptly pointed out, communication today defines sociality. Given that sociality itself is currently situated in significant transformations in the world of physical reality: distance as a condition of security, communication not only determines but also assumes the role of representation, compensation of various manifestations of completeness and integrity of the mental existence of society. That is, information risks are related to how we become aware of our existence in the world of axiomatic informatization and how we organize security measures to prevent direct interference with mental privacy – cognitive subjectivity and at the same time how we preserve sociality as a culture of coexistence.

Due to the need to create conditions for information security, a problem arises and should be addressed by the modern education system. Namely,

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to provide such a qualification to a person (a subject of information and communication relations) as media literacy (Krylova-Grek and Shyshkina, 2020; Yankovych et al., 2019). After all, its absence (absence of media literacy), which means media ignorance, is a convenient basis for conducting information (hybrid) wars, a factor in manipulating consciousness, turning into a victim of suggestion, various forms of dependence, etc. Whereas in the recent past, the media nature of these processes provided for the possibility of evaluating them according to the criteria of reality – virtuality, now these distinctions have lost their firm binarity. On the contrary, they have acquired the qualities of flow, mutual compensation, additions, etc. Today, we can say that virtuality fills all the gaps and physical distances of social reality at least in communicative practices. In other words, the allocation of threats in terms of their truthfulness is insufficient. The response of social, collective and individual consciousness to information, inability to understand, therefore blind trust in the source of the message, ultimately media entertainment or animosity and intrigue, "embedded" in the content of information: all these things become decisive.

2 RELATED WORKS

The problem of media literacy in terms of structure, components, functions was examined in (Christ and Potter, 1998; Potter and Thai, 2019, 2016; Potter, 2004b,a, 2010, 2020; Buckingham, 1986, 1992, 1993, 1995b,a, 1996, 1997b,a, 1999b, 1998, 1999a, 2003, 2006, 2007c,a, 2008, 2009c,b,a, 2013c,a,b, 2015, 2016, 2020); Hobbs (Hobbs, 2017) research deserves special attention since the author continues, develops and clarifies the founders' views of scientific reflection of media literacy. The issue of informational dangers, threats, risks is presented by us in methodological interaction with theoretical studies of media education and in the context of the problem of critical thinking, based on philosophical principles, starting with Aristotle (Aristotle, 1951), Aquinas (Aquinas, 2015), Bacon (Bacon, 2007, 2013), Descartes (Descartes, 2010, 2013, 2014b,a, 2018) and other scholars whose work is fundamental in the development of the epistemological, methodological problems of science. The representatives of American philosophical thought of the twentieth century, James (James, 2001) and Dewey (Dewey, 1997), in the direction of understanding modern alternative approaches to the problem of the formation of "critical thinking" – the basic competence of media literacy. An important concept, in terms of threats to the loss of sensory, spiritual culture – the fullness of social interaction, as a rupture of historical time is Beck's "risk society" (Beck, 2020). The appeal to his theory is methodologically guiding in relation to one of the aspects of digital reality threats, namely the transformation of sensory authenticity as a dominant of the development of human relations and social interaction.

The guidelines of our research, the purpose of understanding the problem of raising public, educational demand for the acquisition of media literacy, are establishing norms of remote interaction as a new reality of communicative culture. Illumination of ignorance in the context of media communication as the growth of threats, information risks in the modern era of the development of the information society and the search for social meanings of preserving the fullness of the culture of human relations in the context of digital reality. The growth of the dangers produced by the various factors of the psychological, intellectual, and ideological insecurity of the subject of media communication determines those aspects of the problem of media literacy, which are becoming tasks for the development of the media education system.

3 PRACTICAL STEPS AND AWARENESS OF MEDIA LITERACY IN THE PREVENTION OF INFORMATION THREATS AND AVOIDANCE OF RISKS DURING A PANDEMIC

The UN and NATO addressed the problem of creating the basis (political, legal, economic, etc.) of information security. The UN and its units are doing significant work in the search for approaches to media education implementation. The United Nations Alliance of Civilizations (UNAOC), in partnership with UNESCO, introduced the Media Center for Media Literacy (https://milunesco.unaoc.org/welcome/) – MIL, a platform for global and multilingual dissemination of media literacy resources, and the publication of articles on media literacy, media literacy policy and youth media (Al-Nasser, 2017). With the help of this platform, teachers can use available topics about media and information literacy in their schools. The website is open to users and allows registered users to upload the content on the website and add information in any language about MIL resources, organizations and events. The interactivity of media communication as a characteristic of this website's functioning is one of the determining factors concerning modern criteria of media literacy.

UNESCO explores the dependency of media leverage and media literacy on hate, radicalization, terrorism and violent extremism. The main achievement is the formulation of the basic principles of information and media literacy development (Grizzle et al., 2013):

1. The implementation of MIL will be most successful in the areas where different stakeholders share their vision and work together to achieve it by sharing knowledge and resources.
2. MIL basics can be developed without access to technology (for example, in oral forms or only in printed forms). However, MIL programs must be available in all existing and new media so that citizens can take full advantage of them.
3. The development of media and information literacy is fundamental to nation-building, economic development, human rights and cultural and linguistic diversity.

A number of international security-focused organizations, from the Organization for Security and Co-operation in Europe (OSCE) to NATO, have identified media literacy as a tool for counteracting hybrid wars because the ability of the audience to think critically and analyze manipulative propaganda contributes to a conscious classification of the veracity of information (Copeland, 2016). NATO's Latvian Strategic Communications Center (NATO StratCom COE) has introduced the News Hero social game designed to help readers identify misinformation on the Internet (NATO StratCom COE, 2018).

In today's reality, in the age of the coronavirus, we are confronted with a large amount of information, and much of it is untrue or unreliable, indicating an urgent need to create new approaches to strengthen our information filtering skills and media literacy development in general. In isolation due to the coronavirus pandemic, we spend much more time online. On the one hand, online life increases the risk of becoming a victim due to the impact of false information; however, at the same time, the style of everyday life in online mode allows the creators of media literacy projects to attract and influence a wider audience through virtual events. For example, Third Media Literacy Days, organized by the Agency for Electronic Media (AEM) and UNICEF under the auspices of the Croatian Ministry of Culture and the Ministry of Science and Education, are being held online this year due to the coronavirus pandemic (UNICEF Croatia, 2020). Undoubtedly, a large number of similar events, international conferences, training courses and seminars were held in 2020 in the format of virtual communication. And this is an essential practical step in implementing the conditions for the formation of media literacy as a factor of information security. To support distance learning, AEM and UNICEF publish video lessons on media literacy for primary and secondary school students, prepared by teachers from different parts of Croatia. They are available on the website https://www.medijskapismenost.hr/.

UNESCO has joined forces with members of the UNESCO-led Global Alliance for Partnership on Media and Information Literacy (GAPMIL) to counter media disinformation caused by COVID-19. To combat disinfodemic (a newly created term that is a combination of the words pandemic and disinformation), the UNESCO-MIL Alliance has taken the following steps:

1. A series of webinars covering various issues related to MIL and COVID-19 disinfodemic. The list of webinars is available at https://en.unesco.org/themes/media-and-information-literacy/gapmil/covid19;
2. Opening free access to educational resources. All available resources can be checked at https://en.unesco.org/sites/default/files/gapmilCOVID-19resources.pdf;
3. UNESCO crowdsourced translations of its handbook, "Journalism, Fake News, and Misinformation", into several new languages in response to the disinfodemic. For further references check (UNESCO, 2020).

Various countries around the world are actively involved in countering the spread of disinformation about the coronavirus. In Ukraine, UNICEF and IN-SCIENCE launched the online competition INFOTON (https://inscience.io/infothone/), during which young people aged 13–25 from Ukraine could create their own media literacy projects on various topics and in various formats. As part of the competition, the teams developed unique projects on the topic of "media literacy" in just 48 hours, with the support of mentors – specialists in the fields of business and media, the industry of creativity, financiers, legal advisers. The three best projects received prizes of 50 thousand hryvnias.

Thanks to INFOTON, young people will be able to encourage and teach their peers to perceive information consciously, work with it, distinguish fact from "fake" (conscious disinformation) – these skills are critical during a pandemic of coronavirus.

In this context, it is also important to mention such initiatives that are focused on deepening media literacy and preventing information risks in connection with the COVID-19 pandemic in different countries and on different continents:

1. The Pakistani newspaper "Dawn" published a short guide (https://www.dawn.com/news/1544256/desi-totkas-and-fake-news-a-guide-to-surviving-the-COVID-19-infodemic) for citizens experiencing disinfodemic as an act of digital media literacy.
2. The African Center for Media Excellence (ACME) offers a list of resources, tools, tips and resources (https://acme-ug.org/2020/03/26/resources-bank-for-journalists-covering-the-coronavirus-pandemic/) related to COVID-19 reporting, including fact-finding.
3. The Afghan NGO NAI has published "Fundamentals of Journalism during COVID-19" (https://nai.org.af/law-and-legal-documents/).

These initiatives are necessary in times of a pandemic, given the circumstances of increasing information risks due to psychological factors, emotional stress, social attitudes of alarmism for fear of life in the face of threats from a little-studied viral phenomenon.

4 RESEARCH OUTLINE AND ANALYSIS OF THE MATERIAL

In our opinion, the introduction of media education in the educational process is an answer to the modern challenges of information risks and threats (Tereshchuk et al., 2019). Therefore, it is a vital step on the way to the upgrading of the modern education system. Even though in 2020, under the influence of circumstances – the threat of losing control over the rate of spread of the coronavirus decease COVID-19, measures to implement distance education are of paramount importance, the very specifics of remote communication are not an educational technology for media literacy. In this case, the media is not a new structure of a content organization with features of information and semiotic systems. It is a communication channel with the appropriate technical means of communication of the educational process subjects as ensuring the functioning of remote interaction. So, the questions remain, both of a theoretical nature – methodology, and practical: regarding the successful integration of media education in the educational process, because the school will have to consider new strategies for presenting information since such a learning process will no longer be conducted according to theoretical principles with a focus on memorization, gradual assimilation of knowledge and assessment. The practical part will serve as a basis and consider the students' experience, the available skills of analysis, and the development of an immediate reaction.

In our opinion, the question arises in terms of the development of the related case technologies and programs concerning the realization of virtual educational practices. Thus, the cognitive, psychological sphere of the educational space will undergo significant changes, and in the long run – the existence of society. It is important to note that the strategic goals of traditional education and media education are as different as the scientific and pedagogical approaches that underlie them: the formation of an intellectually mature or informationally protected, manipulatively invulnerable personality. Obviously, the demand, the request of society is saved on the first version of the strategy and formed on the second. Moreover, in a separate functioning, they do not provide the completeness and harmonious development of the individual in the information society's conditions. It is indicated by both the forecasting of results from the most theoretical approaches and empirical data – the experience of educational institutions in 2020. In particular, maintaining the necessary social distance and the transition to online communication in the educational process of higher education institutions with a large number of students has exacerbated issues of mental and cognitive nature. Only the monitoring of the situation and operational procedures to overcome alienation, loss of professional, cognitive motivation has become a solution to the issues of transformation of sensory authenticity of culture in general and the culture of the educational process in particular. An example of such activities is the project of leisure online communication Tiresij (http://philosophy.kpi.ua/wp-content/uploads/2021/01/TIRESIJ.pdf), which was developed and implemented by the staff of the Department of Philosophy in Igor Sikorsky Kyiv Polytechnic Institute.

The need for this activity is the awareness of members of the staff of the fact that students who were formed under the care (advice, opportunity to see examples of behavioural culture, valuable guidelines, semantic guidelines) of their mentors – teachers, and felt the cohesion of the team: students, graduates, teaching staff of the department, now find themselves in a situation of the isolated location and a single format of interaction: the educational process in online communication. Therefore, it is necessary to create conditions, initiate information platforms for informal interaction with the possibility of implementing cultural activities to consolidate the team to implement social and educational, value-oriented intentions of teachers who are aware of their own responsibility for the future of students.

Undoubtedly, one media practice on the emotional, semantic content of informal interaction cannot compensate for the gap of direct communication as methodological completeness of the educational process. However, the targeted design of events aimed at implementing media practices, with developed techniques for reproducing traditional communication, is one of the elements of balance and risk prevention. We are talking about the risks that arise today in connection with the break of the "real – virtual", "past – future" as "before and after" the 2020 pandemic.

In the context of globalization, according to the concept of Beck (Beck, 1992), risks are formed where the place of the past, which determines the present, takes the future as a determinant of today's processes. In this case, media education can be considered in the potential to preserve the culture of educational practices, not only in providing distance interaction. According to the researcher's theory, we can create a situation of uncontrolled risks as a leap from real to virtual communication because the past is an academic experience, and current educational technologies will not find the fullness of realization in the present.

Thus, the circumstances of the pandemic exacerbated the problem of the need to develop media education as a system focused on, firstly, the implementation of distance forms of communication in online learning and, secondly, the possibility of "new media" (Manovich, 2001) in the formation of interactive communication and resource preservation of content, methods and culture of traditional forms of learning.

The goal of media education is media literacy. In turn, it is based on such components as the need to master critical thinking and techniques for working with audiovisual content, which can reproduce complex multimedia nature and have a multilayer semantic structure.

The study of media literacy is considered multidisciplinary because it is based on the tools and methods of sociological, psychological, pedagogical, political, cultural, gender, racial and other studies. This leads to studies of the concepts of media education and media literacy in various aspects.

For example, from a cognitive perspective, Potter (Potter, 2016) defines media literacy as "a set of perspectives that we actively use to expose ourselves to the mass media to interpret the meaning of the messages we encounter", For Potter (Potter, 2016), the key to creating media literacy is the use of three components: a personal locus, knowledge structures and skills. The personal locus consists of goals that determine the material that can be filtered or ignored by sampling, and drives that determine the amount of effort it takes to achieve the goals. To achieve media literacy, one will also need a solid knowledge structure in five areas: the media industry, media content, media effects, media audiences, on the one hand, and knowledge about the real world, on the other. Possessing good knowledge in abovementioned five areas, a person will be able to make better decisions, search for and work with information and derive meaning from it to meet defined goals. Despite the fact that we consider media literacy in the context of preventing information threats, it can be argued that knowledge of the functioning of the media components is limited and ineffective when it comes to preventing the risks of strategically planned dangerous actions. Finally, we need to use appropriate skills to build knowledge structures. Potter (Potter, 2016) identifies the following skills: analysis, evaluation, grouping, induction, deduction, synthesis and abstraction as the most important tools for regulating the influence of media and increasing media literacy. These methods will be effective in different ways depending on the media content or the specifics of the media audience. However, common in their implementation as dangerous measures is the knowledge of the subject of media activity in the real world. Thus, media literacy does not level but requires education and competence in the traditional sense of knowledge and skills.

Buckingham (Buckingham, 2007b), on the contrary, approaches this issue from a socio-cultural point of view. He notes that recently the term "literacy" clearly has a certain degree of social status, adding that "literacy is a phenomenon that is only realized in and through social practices of various kinds, and it, therefore, takes different forms in different social and cultural contexts". Buckingham (Buckingham, 2007b) points to four broad conceptual aspects that are generally regarded as critical components of media literacy. These include, first, representation: the ability to evaluate the encountered material, for example, by assessing the implicit and explicit motivation of those who created it and by comparing it with other sources, to question the reliability of the represented material. Therefore, the formation of a media literacy platform for this component should be based on the competencies of comparative, analytical, critical comprehension of information through the ability of independent research and belief in the integrity of the source of information. In this aspect, there is a need to establish criteria for integrity and ways to verify it.

Second, language: revolves around the understanding of the structure of the particular forms of communication and functions of languages. This, in our opinion, is the most difficult component of mastering media literacy. It is quite obvious that, being free from restrictions on the circulation of information, media space opens wide perspectives for linguistic simplifications, omissions, inaccuracies, and the contextual content adjusts to the structural limitations of forms of communication. In turn, this causes variability of interpretation, distortion of meanings. Also, the decline in the culture of speech is gaining momentum due to the possibility of anonymous participation in communication and so on. Even a new trend of deliberate disparagement of a language is emerging. Thus, the development of linguistic competence, the high level of lexical, spelling and other requirements are components of information verification, factors in the quality of message evaluation, and the self-discipline of linguistic improvement in media literacy. A separate aspect of this problem is also the semiotic structure of media communication. It is complex, taking into account both the features of the audiovisual text (the role of semiotic structures of signs, symbols on various software, as well as photos, video content, verbal text, etc.) and the multimedia basis of the information and communication activities.

Third, production: understanding who is communicating to whom, and what is the purpose of the conversation. This component, in our opinion, provides for a set of factors of maturity, the preparedness of the subject of media communication: psychological (depth of understanding of the interlocutor, search and acquisition through the communication of a common goal), practically oriented (the goal of media communication is transparent, convincingly formulated and realistic regarding the ways to achieve it), a factor of self-discipline (factors of linguistic, moral and ethical responsibility) and the acquisition of experience as a quantitative and qualitative improvement of the ability of effective media communication.

Fourth, audience: an awareness of one's own position as an audience (reader or user). It includes understanding how media is targeted at audiences and how different audiences use and respond to them. Awareness of the strengths and weaknesses of the target audience makes it vulnerable to hybrid threats. Information threats are possible and arise where the subject of communication is "ready" to accept it. So it is the target audience: those communication participants, whose style of thinking, level of knowledge, value priorities are reflected in particular rhetoric. In the ocean of information, each of us searches for "our" content. In this positive process (searching for like-minded people, interlocutors) the potential of danger is hidden: together with uncritical perception of content and the involvement of sophisticated rhetoric, some people can use us with negative intent, because they push or impose conclusions that have no objective grounds. Thus, sociological competence – understanding the target characteristics of the audience and awareness of rhetoric as a prevention of imposed conclusions – is a media literacy component.

Buckingham (Buckingham, 2007b) points out that media literacy education often focuses on the information component. However, it can be argued that literacy also has a critical dimension. Literacy in this broader sense includes analysis, assessment and critical reflection. This entails mastering metalanguage – that is, a means of describing the forms and structures of a particular mode of communication, and providing a broader understanding of the social, economic and institutional context of communication, and how they influence people's experiences.

The results of the Potter's and Buckingham's studies formed the basis for further research and presented the area of media literacy as an educational, psychological, social and cultural problem that needed to be addressed.

Recent studies by Hobbs (Hobbs, 2015) support the social vision of media literacy: "Media literacy can also be understood as a form of advocacy or as a social movement, aimed in particular at young adults, children, and parents; many see it as a specialized academic field associated with either media studies or education" Although her previous publications adhere to both psychological and social points of view: the term "digital and media literacy" is used to cover the entire range of cognitive, emotional and social competencies, including the use of texts, tools and technologies; critical thinking and analysis skills; message writing practice and creativity; the ability to engage in reflection and ethical thinking; and to participate actively through teamwork and collaboration". Now we have an intensification of the scientific context of reflection of the problem of media literacy and the understanding of the institutional, civilizational scale of social practices that require appropriate condition – the level of media literacy. As a result, the scope of media activity expands, the number and variety of subjects of this activity increases, so it is logical to realize that the increase of information risks, threats and dangers is taking place.

Hobbs and Jensen (Hobbs and Jensen, 2009) identifies five competencies that a person must possess in order to be proficient in digital and media literacy:

1. *Access*: Finding and using media and technology tools skillfully and sharing appropriate and relevant information with others. In our opinion, it

is information awareness, mobility combined with social responsibility: the timely received information and its reliability encourage its dissemination in the environment.

As we see today, in the wake of a pandemic, such media skills can have certain informational threats and negative social consequences. The peculiarity is that even the expert opinion on measures to combat the COVID-19, even in the best version of its presentation in the media content, is a scientific development that has not passed all levels of academic requirements for its accuracy. And the dissemination of such information in the social environment can cause unpredictable threats, psychological trauma etc.

2. *Analyze and Evaluate*: Comprehending messages and using critical thinking to analyze the message's quality, veracity, credibility, and point of view, while considering potential effects or consequences of messages. The first and second competencies, in our opinion, are interconnected in terms of possible information threats. Since the propensity for alarmism, panic, and, therefore, affective actions in case of irresponsible dissemination (or concealment) of information is one of the dangers of the information society. This aspect is especially relevant in connection with the experience we got in 2020.

3. *Create*: Composing or generating content using creativity and confidence in self-expression, with an awareness of purpose, audience, and composition techniques. Creativity as a human need is the driving force of civilization and everyone's natural desire for self-realization. However, it requires a specific starting level of knowledge, developed talents, responsibility since the original content and creative product should not be identical. In our opinion, this is another type of information danger associated with the pseudo-cultural deceptive simplifications of the willingness of everyone to express themselves creatively. Digitalization of information imposes an additional responsibility on the subject of the creativity, since the produced content remains forever, and thus forms an image, reputation, semantic imprint on future activities. Whatever the commercial attractiveness, the process of information creativity must take place in the legal, constructive field of social development.

4. *Reflect*: Applying social responsibility and ethical principles to one's own identity and lived experience, communication behaviour and conduct. In our opinion, this competency fundamentally defines the information space as a human, social space of being. Our identity – an identity in various conditions of communication is not a temporary, episodic phenomenon. It is an in-depth characteristic of a person, the world of culture, spirituality, therefore, leaving "superfluous" – morality – on the shore, and going into the ocean of informational existence without realizing the reality, realness of events, responsibility for them, means breaking the heredity of culture, termination of human history. So the degree of responsibility is extremely high. The real and the virtual world, the genuine and the media presented, must preserve the uniform, moral, spiritual imperatives of universal human existence.

   The above mentioned examples of the social action project "Tiresij" on preserving the completeness and integrity of culture in virtual communication confirm the importance of this criterion of media literacy in online communication as a basis for maintaining social distance during a pandemic, but also the preservation of coexistence, solidarity in interaction - the basis of the moral climate and the avoidance of the trauma of isolation and alienation.

5. *Act*: Working individually and collaboratively to share knowledge and solve problems in the family, the workplace and the community, and participating as a member of a community at local, regional, national and international levels. In our opinion, this competence urges the need to develop various applied knowledge, for instance, in the field of social design. The implementation of this knowledge and abilities in the media education system will open up opportunities and provide a toolbox of actions, methods and forms of collective activity, co-creation and the like.

Meanwhile, Bulger and Davison (Bulger and Davison, 2018) take a psychological, cognitive approach, defining media literacy as a process or a set of skills based on critical thinking. They question the ability of a person to assess credibility as social media personalizes information more and more and provides five broad recommendations for those who are interested in developing the future of media literacy. It is recommended to use the current media crisis to consolidate stakeholders. However, when implementing media security projects in parallel with media attacks and destabilization projects, achieving media literacy is not possible.

It is worth highlighting a recommendation on the development of a holistic understanding of the media environment. The wording of the advice is not limited to five areas as in Potter's works; however, the specific components that need to be mastered to achieve a holistic understanding are not provided. The expected result is the adoption of carefully considered and independent decisions in the processing of information, so we can conclude that one of the components is the use of critical thinking.

5 CRITICAL THINKING IS ONE OF THE MAIN COMPETENCY-BASED STRATEGIES FOR MEDIA EDUCATION

The central concept encountered in all definitions of the above approaches to understanding media literacy is critical thinking. Its only correct definition has not been established, but competing definitions can be considered different concepts of the same basic idea: the goal determines thorough thinking. There is no unity in the theoretical interpretations of the process of thinking. The most common and traditional concept of thinking can be called logical. Logic was historically the first science of thought (Shramko, 2005, 2020). Aristotle investigated it in detail and within the framework of which he examined such components of thinking as concept, judgment, and reasoning. Aristotle speaks of "thinking" as an activity of the higher Mind, praises it as the height of bliss and the joy of life (ru.citaty.net, 2021).

In the Middle Ages, the idea of systematic thinking was embodied in the writings of Thomas Aquinas (Summa Theologica (Aquinas, 2018; Akvinský, 2011; Akvinietis, 2009)). The ability to thinking was considered innate, and thinking was considered separately from the psyche. According to Aquinas (Aquinas, 2018), God gives some of us greater potential for greater depth of thought than He gives to others: "Experience shows that some understand more deeply than others; as one who draws his first principles and final reasons understands it better than one who reduces it to his immediate reasons".

In the Renaissance, scientists again returned to the postulate of antiquity that the psyche is a consequence of the work of the brain. Francis Bacon was concerned with how we misuse our minds in the search for knowledge (Bacon, 2013). He also drew attention to the fact that most people develop bad thinking habits (which he called "idols", "phantoms") that make them believe that they are wrong or deceiving. His book could be considered one of the oldest texts that laid the foundations for the study of critical thinking (Paul et al., 1997). Descartes (Descartes, 2014a), a follower of rationalism, considered thinking an autonomous, rational act, free from direct feeling. At the same time, sensualists, on the basis of the teachings of Condillac (Condillac, 1982), gave a crucial importance to sensation, asserting that "to think means to feel", and the mind is "complicated sensation" (Banshchikov et al., 1967). However, the unifying element of the views of various researchers – representatives of modern thinking, is not only the search for the construction of reliable knowledge, but most importantly – the invention of the foundations of true knowledge. This is an urgent problem in the development of critical thinking today, because the whole construction of mental activity should be based on the foundation of truth, not false judgments.

At the end of the 19th century, a new philosophical tradition appeared – pragmatism. His representative, James (James, 2001), explains what our thoughts consist of: "Our thinking consists more of a sequence of images where some of them evoke others. It's kind of spontaneous daydreaming, and it seems it is likely that higher animals (humans) should be susceptible to them. This type of thinking leads to rational conclusions: both practical and theoretical" (James, 2007).

Another representative of this movement who developed a pragmatic theory of knowledge is Dewey (Dewey, 1997). Hi first used the term "critical thinking" to describe a teaching goal, although more often, he used the term "reflective thinking". He defined it as an active, persistent and careful consideration of any belief or intended form of knowledge, given the reasons that support it and the subsequent conclusions to which it is inclined.

Critical thinking is self-governing, self-disciplined, self-controlled and self-correcting thinking (it faces the face and contrasts with Potter's media-focused components). This type of thinking involves accepting strict standards of excellence and conscious ownership of them. As a result, a person gains the ability to communicate effectively and solve problems.

The problem of our study is information security as the purpose of media activity. It is worth saying that information security, in our opinion, is fundamentally different from a sense of danger in the pre-information society. In the periods of the twentieth century and earlier, security correlated with confidence in the absence of threats of a different nature. For example, the financial and economic downturn, external conquests, social transformations and etc. Actually, this moral comfort – confidence, reflected the nature of the security of investments in the actions of the authorities in such a form as trust. On the peculiarities of entering the stage of the information society, security cannot be fully implantable in certain state institutions, since the nature of information processes: communication, openness, minimal control over various kinds of media, has globalization specifics. Therefore, security policy responsibility in a significant component relies on the user of information networks. And therefore, a sense of trust in the way of shifting the security functions to the structures of the external plan can just make it fall into the danger zone. Today, all the levers of control are concentrated in the information, and the subject of its creation, distribution may remain anonymous or, at least for some time, unknown. Thus, the situation of an uncontrolled, from the side of a person – the subject of media communication, usage of the capabilities of information networks can carry threats, starting with manipulative influence, including the outbreak of social protests and ending with hybrid wars. In fact, in the aspect of information security, not only an important but also a necessary preventive means of building social and communicative relationships is acquiring of media literacy. Critical thinking is one of the elements of media literacy, which in turn is one of a set of measures designed to achieve a state of security of information needs of individuals, society and the state.

The information platform is increasingly used as a bridgehead for bringing about conflicts of various scope. Media literacy can be an option of confrontation. On the one hand, it is characterized by its impact on systems for receiving, processing, disseminating and storing information that may hypothetically carry certain dangers. A media educated person will not be able to turn a blind eye to the manifestations of media attacks, so he/she will actively perceive them to produce a response – a reaction. Although this answer leaves a chance of being mistaken, in a situation with information ignorance, the risk of positive (i.e., the risk of becoming a victim of moral, psychological, ideological influence) perception of media attack is exceptionally high. And even if a media illiterate person does not show an apparent aggressive reaction, gives the impression of a complete lack of understanding or ignore the attack, information aggression will be successful at a subconscious level, because the process of critical thinking and analysis based on the conscious knowledge of strict standards was not actualized. On the other hand, possessing media literacy will make it possible to draw conclusions from attacks by an information-aggressive manipulator and to apply measures to protect their similar systems from destructive and controlling influence.

6 CONCLUSION

Thus, the experience of social and educational interaction in the large-scale implementation of online communication in 2020, as a necessary component of vital security – social distance during the pandemic, has exacerbated the relevance of media literacy as a system of protection against information threats. The scientific developments, practical measures and project trends considered in the article in the criteria “before” and “during” the pandemic provide an opportunity to draw conclusions about the following. Media literacy is a necessary component of modern education, as its demand has been revealed in the context of global challenges and dynamic changes in the vital norms of social reality. Experience related to counteraction, prevention of viral threats, namely, remote communication based on the multimedia system of the information society, has shown an important mission, which is entrusted to the subjects of media activities, especially the organization of media education. It is the awareness and consideration of the risks associated with the rupture of communicative culture in terms of its direct and media functioning. Thus, the search for social meanings of preserving the completeness of the culture of human relations in digital reality conditions is a necessary task. Media literacy does not involve the opposition of real and virtual but provides an opportunity to preserve the meanings of real reality as a basic criterion for information interaction.

So media literacy does constitute a constructive opposition to the violators of the world of information relations – the subjects of illegal, immoral, manipulative actions, adds a resource of confidence, the basis of independence regarding the successful choice of tools to counter information aggression or even war. An important task arises – to master the media literacy in the conditions when we are already subjects of relations and are in the active phase of the development of the information society. Scholars have made many suggestions as to where and how they believe media literacy should be taught, in what way it should be mastered, and how this type of learning should be evaluated. As an ambivalent process in terms of the potential of mental threats and insecurity against ideological aggression, we think that informatization expands the range of dangerous informational influence (from suggestion to war). However, informatization of education through the development of a media literacy system is a way of positive development, since it lays the foundation for entry into the reality of modern information relations. For each era, historical period, education was and remains a way of acquiring the foundations of cultural interaction in society. Today, paradoxically, as it sounds, given the globalization expansion of social contacts, information relations, the personal responsibility of a person is growing. Therefore, a special socially-constructing function is assigned to the resource of media education: to form media literacy, to prevent information threats, to develop the intellectual, creative resource of a participant in communicative relations. Today it is difficult to predict all the dangers that humanity expects in such a radical transition to a historically new informational reality, but the basis for their prevention is the responsibility of each of us in mastering media competence and developing a culture of the information society.

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Prospects of Quantum Informatics and the Study of Its Basics in the School Course

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Keywords: Quantum Calculations, Quantum Computer, Quantum Circuit, Quantum Algorithm, IBM Quantum Experience, Python, Jupyter Notebook.

Abstract: The purpose of this study is to review the main points of the experimental content of the basics of quantum computer science adapted for lyceum students, based on the prospects of the quantum approach to information processing for ultra-fast calculations in modeling objects of complex dynamical systems. In addition, software tools and Internet services are offered to organize effective training.

1 INTRODUCTION

According to experts, the modern IT market is in the initial state of another technological breakthrough due to integration (interpenetration, convergence) of 1) nanotechnologies (the ability to control matter at the atomic level), 2) biotechnologies (the ability to manipulate genes and genetic information), 3) information technologies (the use of communication and communication tools) and 4) cognitive technologies (the study of the fundamental essence of thought processes and their mechanisms) (Sigov et al., 2019).

The capabilities of modern supercomputers (“computers of classical architecture”, “classical computer”) are no longer enough for efficient processing of large amounts of data during modeling of nanoobjects, biogenetic systems, cognitive processes, and other phenomena. It is felt that the development of transistor computers has almost reached its limit and that Moore’s Law, which consists in doubling the computer power every one and a half to two years, will soon cease to hold since the size of transistors will stop decreasing every 18 months (Rotman, 2020; Fog, 2015; Al-Kilani and Umkeeva, 2016). A quantum approach has a significant potential for data processing (information), for increasing the productivity of cumbersome and secure calculations, for reliable storage of their results in scientific fields, in logistics, safe trade, and finance, i.e. new computer science – quantum information science, or quantum informatics.

Quantum informatics (as a new branch of science, the subject of which is the theory and practice of using quantum objects for transmission and procession of quantum information), in addition to quantum information theory and quantum algorithms, includes physics and mathematics of quantum computers, problems of decoherence description, measurement problems, issues of quantum cryptography, simulation modeling of quantum systems, quantum intelligence, etc.

Leading IT companies, in particular, IBM (since 2016), Intel (since 2017), and Microsoft offer free access to experimental models of next-generation computers as an Internet service (IBM, 2021; Microsoft, 2021; Amazon, 2021) to all interested parties. However, school computer science course, which is updated every 3–5 years, does not address at all either the general principles of functioning of quantum computers and the peculiarities of their management or the fundamental principles of quantum computer science.

Taking into account the prospects of quantum modeling of complex systems of various nature, particularly cryptographic, chemical, and economic (Ackerman, 2021; YouTube, 2020, 2019), we con-

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sider it appropriate and possible to generalize, systematize, and adapt the basics of quantum informatics for mastering it by lyceum students.

2 RESULTS AND DISCUSSION

The study of the basics of quantum informatics and programming is proposed to be organized either within the framework of a new (experimental) sample module of the same name – "Fundamentals of Quantum Informatics and Programming" – a standard-level program for pupils of 10-11th grades, or, in an extended version, within the framework of the same elective course, the amount of study hours is 17 and 35, respectively.

The purpose of teaching the sample module (elective course) "Fundamentals of Quantum Informatics and Programming" (table 1) there should be the development of the components of computer literacy and information culture of lyceum students through the acquisition of basic theoretical knowledge and practical skills to manage quantum computers as new generation computers.

To achieve this goal (according to the content presented in table 1), it is planned to solve the following tasks:

- to form the concepts of "quantum computer", "qubit", "quantum superposition", "quantum logic gate", "quantum algorithm", "quantum circuit", "quantum entanglement", "quantum programming language", etc.;
- to acquaint with the history of formation, the current state, and development prospects of quantum informatics;
- to introduce physical and mathematical foundations of quantum computing;
- to study the potential and determine the advantages of quantum computers for solving individual applied problems, modeling problems of complex systems of various nature, etc.;
- teach the pupils to implement basic quantum algorithms in special and universal environments with remote and local access.

The expected results of mastering the educational material of the first three lessons – "Digital technologies: history of formation, current state, development prospects", "Basics of classical computer arithmetic", and "Basics of classical computer logic" are as follows:

- student explains the concepts of digital technologies, classical computers, processor and memory of a classic computer; number system, number system alphabet, basis of the positional number system; binary message code, length of binary message code, units of measurement for the length of binary message code;
- student knows the quantum computer definition, general principles of its structure and functioning, and the peculiarities of its using;
- student understands the typical architecture of a classic computer and the general principles of its operation;
- student names the units of measurement of the length of the binary message code (bits, bytes, kilobytes, megabytes, gigabytes, terabytes);
- student describes the general principles of operation of the processor and internal storage devices;
- student is able to convert natural numbers from decimal to binary and vice versa; determine the length of the binary message code; arithmetic addition and multiplication of binary numbers; logical operations not, and, or, xor over binary numbers;
- student is aware of the role of existing (classical) digital technologies and the significance of their development prospects.

In particular, a quantum computer should be understood as a computing device which CPU is based on the logic of quantum mechanics. Such a computer is fundamentally different from a classical computer (a computer of the von Neumann architecture) and uses for calculations not classical algorithms of the macrocosm, but algorithms of phenomena of the microcosm of quantum nature, based on quantum parallelism and quantum entanglement (connectivity) (Bernhardt, 2019).

The expected results of mastering the learning material of the next three lessons of the module – "Complex numbers fundamentals", "Working with objects of linear algebra: vectors", and "Working with objects of linear algebra: matrices" should be as follows: student

- student explains the concept of a complex number; vector, row vector (bra vector), column vector (ket vector), orthonormal basis, standard basis, linear combination (superposition) of vectors; matrix, square matrix, unit matrix, orthogonal matrix, unitary matrix;
- student knows about the Euclidean and Hilbert spaces;
- student is able to determine the real and imaginary part of a complex number written in alge-

Table 1: "Fundamentals of Quantum Informatics and Programming": draft content of the sample module (17 hours).

No	Topics
1	Digital technologies: history of formation, current state, prospects of development
2	Basics of classical computer arithmetic
3	Basics of classical computer logic
4	Complex numbers fundamentals
5	Working with linear algebra objects: vectors
6	Working with linear algebra objects: matrices
7	Key concepts of quantum computing
8	Quantum circuits and their design environments
9	Quantum NOT gate
10	Hadamard quantum gate
11	Quantum CNOT gate
12	Quantum Toffoli and Fredkin gates
13	Basic quantum algorithms and peculiarities of their implementation using a programming language
14	Quantum teleportation algorithm
15	Deutsch–Jozsa algorithm
16	Shor's algorithm
17	Grover's algorithm

braic form; perform operations on vectors (addition, scalar, and tensor multiplication, determination of coordinates in a new basis) and matrices (transposition, multiplication by a number, matrix multiplication, inversion);

- student understands the role of vector-matrix apparatus in quantum informatics.

After propaedeutics of the basics of quantum programming, it is the turn of the first main section – "Fundamentals of quantum computing using algorithms implemented in circuits". For 6 lessons students should get the following abilities:

- explain the concept of a qubit, spin, qubit state, quantum superposition, qubit measurement, qubit entanglement, quantum algorithm, quantum circuit quantum gate, purpose and content of basic quantum gates (NOT, Hadamard, CNOT, Toffoli, Fredkin);
- distinguish between reversible and irreversible operations;
- establish a correspondence between the matrix operator and the quantum gate designation in quantum circuits;
- be able to build basic quantum circuits in a special environment, use the necessary quantum gates and interpret the obtained results.

In the first lesson of the section, students should learn that the basis of quantum computing is a qubit (quantum bit). To explain the concept of "qubit", it is necessary to use the method of analogy (with the classical bit) and the ideas of quantum mechanics.

The teacher states that quantum particles have certain characteristics that can be used to describe their behavior and that can be determined in practice (and therefore implemented in quantum computers). In particular, photons have a polarization, which is determined by the behavior of the vector of their electric field; some microparticles have their own magnetic moment (spin), the projections of which on the direction of the outer magnetic layer are found experimentally (Bernhardt, 2019). The teacher recalls that the concept of bit is used in traditional calculations. It is based on the fact that technically only two states can be realized: 0 and 1 – for example, the current flows or does not flow (that is, there is a charge or there is no charge) (figure 1).

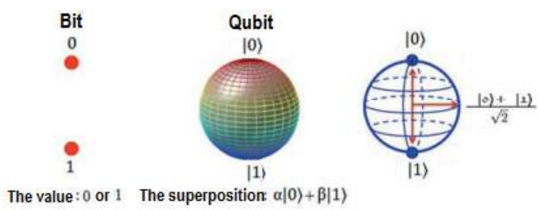

Figure 1: Qubit representation.

Talking about qubits, the teacher focuses students' attention on the fact that a qubit may have not only two states (for example, the spin of a quantum particle is located in the direction of the external field – 0 or against – 1), but also their superposition, due to the quantum nature of the phenomena of a microcosm. The superposition of the qubit states is represented graphically as a coordinate grid on a sphere, where each node corresponds to a certain state (see the central part of figure 1).

If the base states of the qubit are denoted as $|0\rangle$ (ket vector with coordinates $(1,0)$, which describes the spin direction of the quantum particle against the external field) and $|1\rangle$ (ket vector with coordinates $(0,1)$, which describes the spin direction of a quantum particle along an external field), then any other state from the set of possible states will be determined by the relation (linear combination, superposition):

$$\alpha|0\rangle + \beta|1\rangle,$$

where α and β are complex numbers that satisfy the relation $|\alpha|^2 + |\beta|^2 = 1$; $|\alpha|^2$ and $|\beta|^2$ represent probability amplitudes of transition to the states $|0\rangle$ and $|1\rangle$.

Qubits can be connected (entangled) with each other. This means that a connection can be established between them, as a result of which each time changing the state of one of several qubits, the rest change in accordance with it, and the set of entangled qubits is interpreted as a filled quantum register. Like a single qubit, the quantum register is much more complex than the classical bit register. It is able not only to be in all possible combinations of its constituent bits but also to implement subtle relationships between them, which significantly increases the computational power of systems based on qubits.

In the state of entanglement and superposition, qubits represent a quantum register. During calculations in the quantum register, the amplitudes of qubits ($|\alpha|^2$ and $|\beta|^2$) are arranged in such a way that positive values of the amplitude of one qubit neutralize the negative amplitudes of another qubit, and computational errors are canceled (positive amplitudes of qubits, on the contrary, amplify each other). This is how the scenario of getting the correct answer is formed.

Explaining the differences in the principles of classical and quantum computers, teachers turn to the problem of finding a way out of the maze, using the example of which they illustrate and convince that the classical computer consistently goes through all ways, hitting a dead end once at once, but the quantum computer can check all possible variants at once (Sigov et al., 2019). Next, teachers focus attention and interest, especially of bright and inquisitive students, on the fact that the main engineering complexity of the implementation of quantum processor registers is to maintain the state of superposition and entanglement of qubits during calculations (measurements) – coherence time.

The calculations in a quantum computer are performed using quantum algorithms. It is proposed to be understood as an algorithm containing a finite sequence of unitary (reversible) operations/gates with an indication of the qubits on which they need to be performed. The correctness of the calculation result using the corresponding quantum algorithm is determined with a certain probability. To increase the probability of getting a correct outcome in quantum algorithms, the multiplicity of operations is especially increased, which are selected in such a way that incorrect results are mutually destroyed with a high probability, and the probability of a correct result increases.

The last section – "Basic quantum algorithms and their implementation on circuits and using a programming language" – is the second main section of the sample module, because the expected results of mastering it that the student:

- knows the particularities of the implementation of quantum algorithms in an environment with remote access and a local one; the basics of the syntax of quantum algorithm implementation by a general-purpose programming language;
- understands the basic concepts of quantum algorithms;
- explains the step-by-step structure of basic quantum algorithms;
- uses the capabilities of remote and/or local access environment to implement quantum algorithms in the form of circuits and programs;
- implements and executes basic quantum algorithms in a special environment using a general-purpose programming language and the graphical editor;
- is aware of the effectiveness of quantum computing in comparison with classical ones;
- evaluates the compliance of the results of the program with the task at hand;
- follows the rules for writing readable code and comments to it, explains the code to others;
- checks, hypothesizes, critically evaluates, identifies the shortcomings of the implemented algorithms.

Problems that can be solved with the help of quantum computers can also be solved on the computational basis of classical computers. However, the advantage of quantum computers, or more precisely, quantum algorithms (Zahorodko et al., 2021), is to reduce the time spent on solving the problem by parallelizing operations through the generation of entangled quantum states and their further use. Such cases are called quantum acceleration. The application of quantum acceleration is the most advantageous when solving problems of modeling complex dynamical systems, mathematical search problems, in a particular search.

The main advantages of quantum computers and algorithms in comparison with classical ones are the effective solution of *quantum cryptography problems* and *problems of simulation modeling of quantum systems*.

To master the training material of the module/course, in particular, to acquire practical skills in the field of quantum computing, students are offered to work with universal and special software and Internet services:

1) for building the quantum circuit using drag-and-drop technology in remote mode – Circuit Composer from IBM Quantum Experience Lab (figure 2, (IBM, 2021));
2) to master the mathematical foundations of quantum calculations and the implementation of basic quantum algorithms in the local mode of Anaconda Navigator environment – the manager of packages and programming environments (figure 3);
3) for studying the mathematical foundations of quantum calculations and the implementation of basic quantum algorithms remotely using Collaborative Calculation and Data Science cloud-based educational and scientific natural information environment (CoCalc).

CoCalc (figure 4, (CoCalc, 2021)) is an entire computer lab in the cloud where:

- each student works 100% online – in their own, isolated workspace;
- you can follow the progress of each student in real-time;
- at any time you can jump into a file of a student, right where they are working;
- you can use TimeTravel to see each step a student took to get a solution;
- integrated chat rooms allow you to guide students directly where they work or discuss collected files with your teaching assistants;
- the project's activity log records exactly when and by whom a file was accessed.

The author's team is developing a set of educational and methodical materials, which includes:

- educational and methodical manual;
- collection of educational presentations;
- collection of educational video podcasts;
- electronic workbook;
- bank of test tasks.

After finishing the development of a set of educational materials adapted for students, it will be possible to move on to a large-scale experiment on studying the basics of quantum informatics and programming by the lyceum students.

A survey was conducted among computer science teachers of general secondary education institutions to study the expediency and readiness of teachers to teach the course “Fundamentals of Quantum Informatics and Programming” for lyceum students. 26 teachers of Computer Science, Chemistry, Technology, and Mathematics took part in the survey, the vast majority of them live in a city of regional subordination. The age of teachers who answered the questions was as follows: 7.7% – 25–35 years; 30.8% – 25–35 years, 42.3% – 35–45 years, 15% – 45–55 years; 3.8% – over 55 years.

100% of respondents supported the statement that secondary education should provide up-to-date knowledge and take into account modern achievements of the industry when studying the discipline. All respondents indicated that they use cloud technologies when teaching their subject (65.4% – always, 34.6% – during distance learning).

Only one survey participant disagreed with the fact that the training material can and should be adapted according to age.

96.2% of teachers indicated that they are happy to accept the introduction of new sections and topics in the curriculum of the discipline, especially if there is sufficient and high-quality methodological support.

Responses from respondent teachers indicate that 88.5% of those who took part in the survey expressed the opinion that they would like to personally take the course “Fundamentals of Quantum Informatics and Programming”, and 38.5% of them said that they had met many publications on this topic and were interested. 61.6% of teachers said that you would offer a course “Fundamentals of Quantum Informatics and Programming” for applicants for education in your institution. 23.1% refused because, in their opinion, this course would not correspond to the profile of the educational institution where they work. Only 3.8% answered “no”. The survey shows that teachers follow new trends in the development of the industry and are ready to teach students in their institution modern and relevant courses. Regarding the study of “Fundamentals of Quantum Informatics and Programming” in lyceums, the interviewed teachers expressed their support for the implementation of this course if there is an appropriate course for teachers and methodological support.

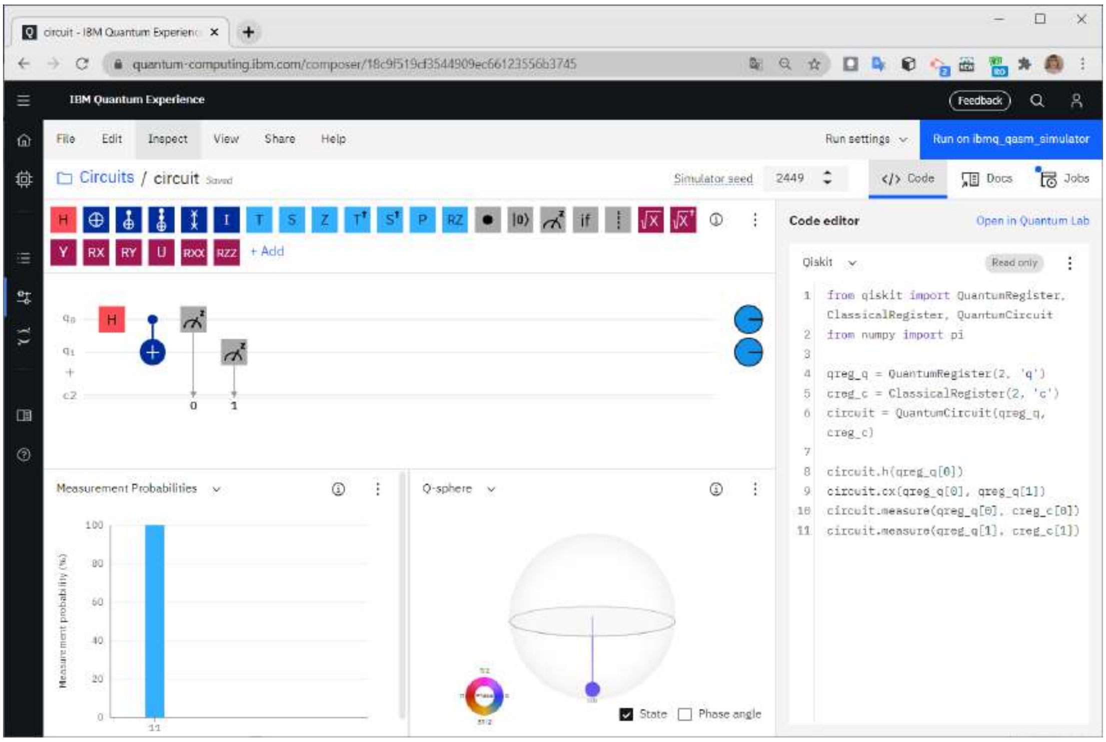

Figure 2: Page with quantum circuit composer from IBM Quantum Experience.

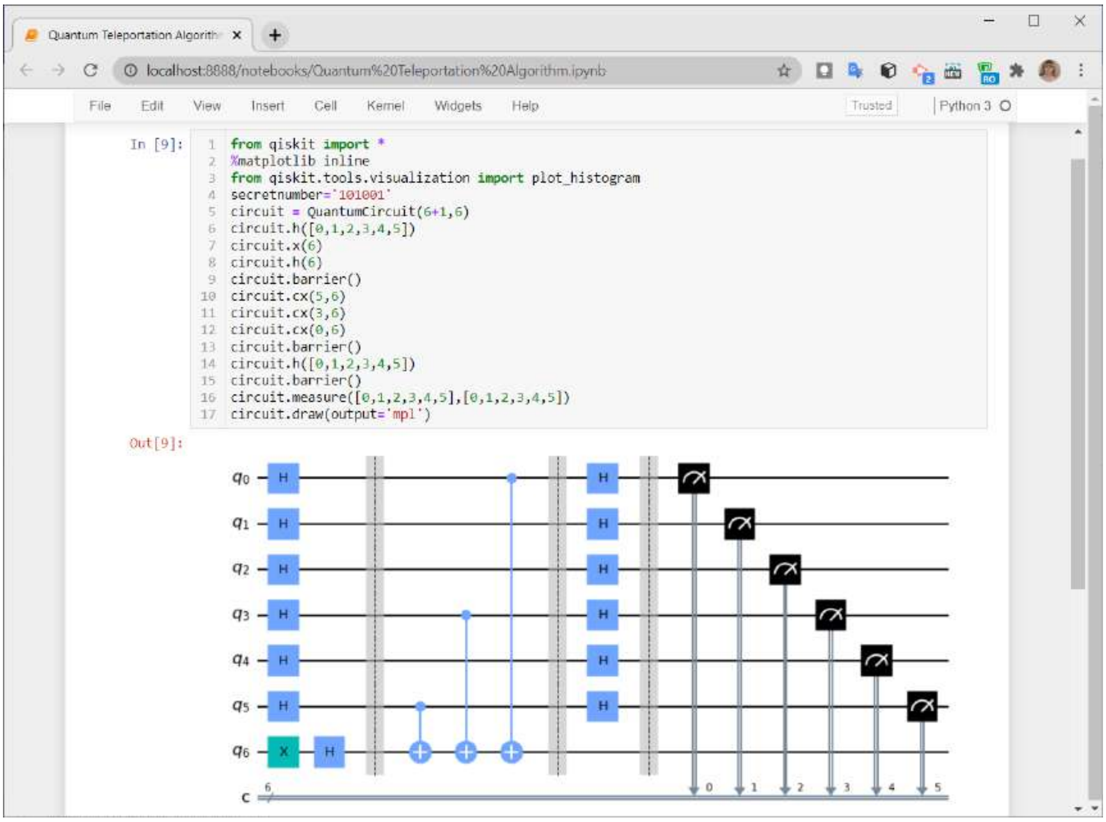

Figure 3: Jupyter notebook page in local access.

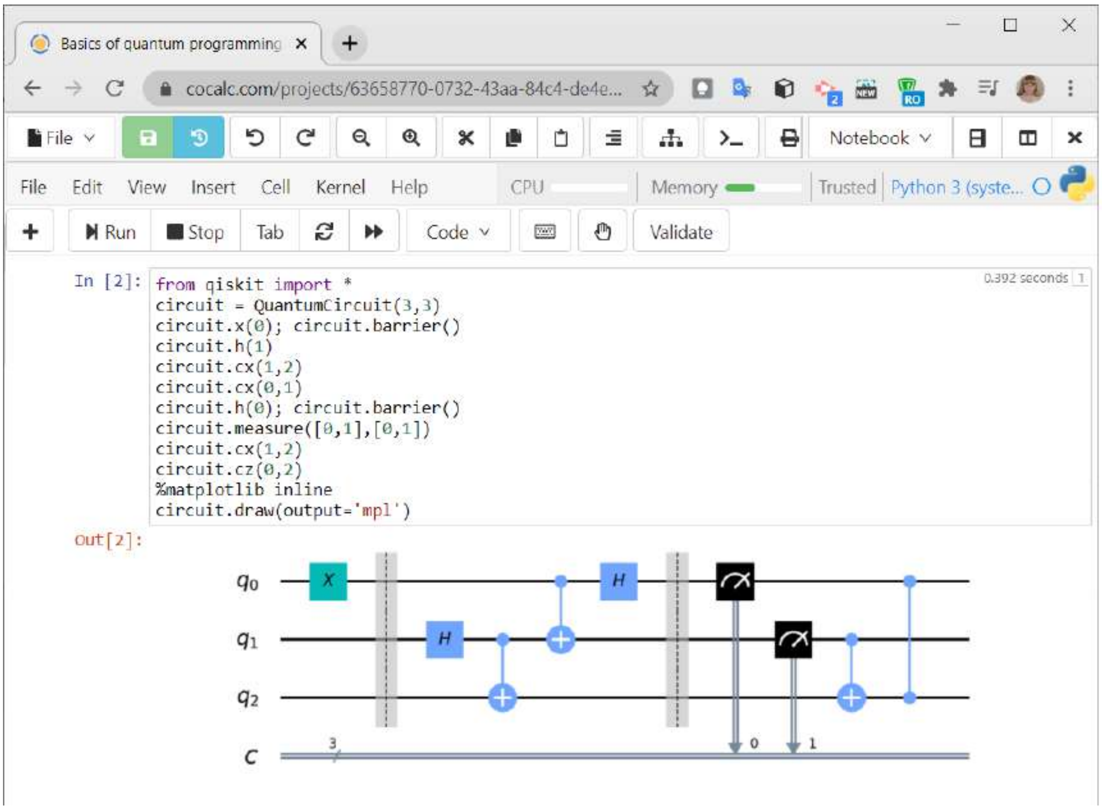

Figure 4: Jupyter notebook page in the CoCalc cloud environment.

3 CONCLUSIONS

1. The new branch of computer science – quantum computer science – has significant potential for increasing the productivity of cumbersome and secure computing, for reliable storage of their results in scientific fields, in the spheres of logistics, safe trade, and finance.
2. It is proposed to start studying the basics quantum computer science and programming in the school computer science course (obligatory-selective for students of grades 10-11) within the framework of a new (experimental) module (17 hours) according to the lyceum curriculum of the standard level or an elective course (35 hours) of the profile level curriculum.
3. For effective studying of the training material, students are offered to work with universal and special software and Internet-services – IBM Quantum Experience, Jupyter Notebook using Python programming language (in remote or local access).

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The Use of Ensemble Classification and Clustering Methods of Machine Learning in the Study of Internet Addiction of Students

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Abstract: One of the relevant current vectors of study in machine learning is the analysis of the application peculiarities for methods of solving a specific problem. We will study this issue on the example of methods of solving the clustering and classification problem. Currently, we have a considerable number of machine learning algorithms – e.g. Expectation Maximization, Farthest First, K-Means, Expectation-Maximization, Hierarchical Clustering, Support vector machines, K-nearest neighbor, Logistic regression, Random Forest etc. – which can be used for clustering and classification. However, not all methods can be used for solving a specific task. The article describes the technology of empirical comparison of methods of clustering and classification problems solving using WEKA free software for machine learning. Empirical comparison of data clustering methods was based on the results of a survey conducted among students majoring in Computer Studies and dedicated to detecting signs of Internet Addiction (IA) (Internet Addiction is a behavioural disorder that occurs due to Internet misuse). As a continuation of the study of Internet Addiction of students, a survey of students of other specialties was conducted. Ensemble methods of machine learning classification were used to analyze these data. Empirical comparison of clustering algorithms (Expectation Maximization, Farthest First and K-Means) and ensemble classification algorithms (AdaBoost, Bagging, Random Forest and Vote) with the application of the WEKA machine learning system had the following results: it described the peculiarities of application of these methods in feature clustering and classification, the authors developed data instances' clustering and classification models to detect signs of Internet addiction among students, the study concludes that these methods may be applicable to development of models detecting respondents with signs of IA related disorders and risk groups.

1 INTRODUCTION

One of the areas of research, particularly, such as education, healthcare and life safety, is the empirical analysis of methods of solving a specific problem with the using of the machine learning (Zahorodko et al., 2021; Zelinska, 2020). Let us study this issue on the example of methods of solving the clustering and classification problems (Tarasenko et al., 2019).

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Clustering methods are statistic methods of data analysis that enable people to group the given selection of data samples into clusters, classes, taxons depending on the value of their attributes; each of these groups has certain characteristics. The main idea is to use several clustering methods in order to carry out an empirical comparison study and determine which methods ensure the most optimal data grouping while solving a specific problem.

Machine learning classifies clustering problems as problems for unsupervised learning. Currently, there is a considerable number of machine learning algorithms that can be used for clustering, for instance, Expectation Maximization, Farthest First, K-Means,

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K-Medians, Hierarchical Clustering etc. But not all of them are suitable for solving a specific problem. Data clustering algorithms differ by the cluster model type, the algorithm model type, the nesting hierarchy of clusters, the way of implementation depending on the data set etc. Because of this, there are also certain requirements to the data set parameters.

Classification tasks are considered to be a different group of machine learning tasks – namely, supervised learning. However, nowadays, there are developed classification algorithms based on a combination of supervised learning and unsupervised learning (e.g., Learning Vector Quantization) the classification algorithm in machine learning is built on the basis of the preset finite number of objects divided into groups and allows to classify an arbitrary object, if it is unknown which group it belongs to. There is a considerable number of machine learning algorithms that can be applied to solve classification tasks, e.g. Support vector machines (SVMs), Logistic regression, K-nearest neighbor, Linear discriminant analysis (LDA), etc. However, currently, one can get more accurate results by using ensemble methods.

Popular software products used in machine learning include TensorFlow, WEKA, MATLAB, MXNet, Torch, PyTorch, Microsoft Azure Machine Learning Studio and others.

In this study, we use the WEKA (Waikato Environment for Knowledge Analysis) free machine learning software (Weka, 2021). The free WEKA machine learning system gives direct access to the library of implemented algorithms written in Java.

Analysis of contemporary studies and publications shows that the issue of analysis and selection of the machine learning method, which would be optimal for processing a concrete data set, is popular in the scientific circles. A considerable number of these studies is dedicated to the application of machine learning methods in the fields of education, healthcare and life safety.

In healthcare and education sentiment analysis becomes more and more popular. Thus, Pacol and Palaoag (Pacol and Palaoag, 2020) conducted the sentiment analysis of the Textual Feedback of students regarding the work of the professors using Machine Learning Techniques. In the sentiment classification study, the Random Forest algorithm proved to be most effective; it proved to be more effective than base models of Support vector machines, Naive Bayes, Logistic regression algorithms and their ensembles (Pacol and Palaoag, 2020).

Klochko et al. (Klochko et al., 2020) applied clustering algorithms of machine learning for the analysis of typical mistakes pupils make, the selection and adaptation of the content of learning to concrete groups of pupils that was then supposed to be used for flipped learning with the use of virtual learning environment. The analysis was done through the comparison of clusters, defined by learning results demonstrated by the pupils, using Canopy, Expectation Maximization and Farthest First algorithms.

Souri et al. (Souri et al., 2020) suggested a model based on the Internet of Things technologies for monitoring the indicators of students' health in order to detect biological and behavioral changes. The developed model, when used together with the Support Vector Machine (SVM) algorithm, reaches the highest accuracy of 99.1% (Souri et al., 2020).

Hussain et al. (Hussain et al., 2019) studied the application of the machine learning classification methods to find ways to ensure independent daily living of people who have Alzheimer's disease. The idea of the study is to analyze the data registered by different equipment in order to determine the changes in a person's behavior that are relevant for the daily life and social interaction. The paper gives a comparison of the efficiency levels of five machine learning classification techniques used for the recognition of a person's activity (and his/her psychological status). Experimental findings show that compared to traditional methodologies, these approaches give better results in determining the activity of the person and his/her psychological and behavioral peculiarities.

Krämer et al. (Krämer et al., 2019) studied the speed and efficiency of medical aid provision using the databases of the Hospital ER. Applying the Random forest algorithm, the authors developed the model based on the data about the patient's provisional diagnosis. The use of the controlled machine learning method and model training based on the opinion of a specialized doctor allowed them to achieve high forecasting accuracy (96%) as well as the area under the receiver operating curve (>0.99).

Subasi et al. (Subasi et al., 2019) developed a hybrid model of detecting epileptic fits using the Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) to determine the optimal parameters of application of the Support Vector Machine (SVM) algorithm. The hybrid algorithm that they suggested can demonstrate data set classification accuracy of up to 99.38%.

A considerable number of papers appeared, which are dedicated to diagnosing Internet addiction (IA) and studying the mechanisms of this disorder among various social groups. The appearance and use of the Internet has many benefits. However, at the same time, disorders related to pathological use of the Internet are becoming a social as well as a psychological problem. Currently, we face an important psychological, sociocultural and educational issue of detection and prevention of certain pathologies and steady premorbid conditions (state before the disease) caused by inadequate Internet use. Cases of IA were first mentioned in 1995 and attracted considerable attention. Issues related to this one became the research subject of Yuryeva and Bolbot (Yuryeva and Bolbot, 2006), Derhach (Derhach, 2016) and others. Internet Addiction Disorder (IAD) is also called Pathological Internet Use (PIU). The term "Internet Addiction" was first suggested by Ivan K. Goldberg in 1995. He describes net addiction as a specific pathology characterized by a wide spectrum of behavioral and impulse control disorders (lack of control, absence of voluntary regulation) (Abbott et al., 1995). In 1996 Goldberg made the first attempt to determine groups of behavioural and psychological signs and symptoms of IA (Wallis, 1997), namely: tolerance; abstinence syndrome; difficulties in voluntary regulation of Internet-behaviour; increase of time and financial investments in things related to Internet or computer use; a shift of a person's interests towards Internet-related activities; extensive Internet use that leads to maladjustment. In 1998 Young (Young, 1998a,b) defined IAD as an impulsive-compulsive disorder, which has specific signs or addictions: cyber-sexual addiction, cyber-relationship addiction, net compulsions, information overload and computer addiction. IAD is not officially included into ICD-11 for Mortality and Morbidity Statistics (Version: 09/2020), however, in section 6C51 Gaming disorder the "Gaming disorder" is described as a "pattern of persistent or recurrent gaming behaviour ('digital gaming' or 'video-gaming'), which may be online (i.e., over the Internet)" (ICD-11 for Mortality and Morbidity Statistics , Version: 09/2020).

Even though the problem of IA is becoming more and more relevant, there are not enough scientific papers dedicated to the study of this issue with the help of machine learning methods. Let us look at some of them. On the basis of the Support Vector Machine algorithm, including the C-SVM and v-SVM, and applying the Student's t-test to the data set of the survey conducted among 2,397 Chinese students, Di et al. (Di et al., 2019) proved the utility of using machine learning methods for detecting and forecasting the risk of IA. Hsieh et al. (Hsieh et al., 2019) suggested using the EMBAR protected system of web-services based on the ensemble classification methods and case-based reasoning to study the IA of the users and prevent the development of this disorder at the initial stages. Ji et al. (Ji et al., 2019) are currently continuing their research, which aims to create an IA detector that would work in a real-time mode. The authors suggest studying this issue using an adapted system of continuous real-coded variables (XCSR), which determines the level of Internet addiction (high-risk and low-risk) on the basis of the information about the Internet users using the Chen Internet addiction scale (CIAS) or respiratory instantaneous frequency (IF). Suma et al. (Suma et al., 2021) studied the possibilities for predicting IA based on a set of predictor variables using the Random forest algorithm.

Thus, based on the above presented statement of the problem as well as taking into consideration the insufficient amount of research on the application of machine learning methods to IA diagnosing, we determine the aim of our research, which is to determine the fields of use and conduct an empirical comparison of ensemble classification and clustering methods of machine learning in the study of IA disorder of students.

2 SELECTION OF METHODS AND DIAGNOSTICS

The study of IA disorder of pupils had two stages. The first sage was conducted in 2019, its purpose was to determine the possible fields of use as well as an empirical comparison of clustering methods of machine learning for studying IA disorders of students. During the second stage, in 2019–2021, the authors studied possible fields of use as well as an empirical comparison of ensemble classification methods of machine learning for studying IA disorders of students.

At the first stage, data regarding the spread and severity of IA among students majoring in Computer Sciences were received from an online survey, which used a questionnaire drafted with the help of Google Forms. 262 students majoring in Computer Sciences and coming from different regions of Ukraine participated in the experimental study. The data set is presented in the ARFF format and consists of 8 attributes (figure 1) (Klochko and Fedorets, 2019). The data set contains the fields described in table 1.

Cluster analysis is one of the tasks of database mining. Cluster analysis is a set of methods of multidimensional observations or objects classification, based on defining the concept of distance between the objects and their subsequent grouping (into clusters, taxons, classes). The selection of a concrete cluster analysis method depends on the purpose of classification (Klochko, 2019). At the same time, one does not need a priori information about the statistical popula-

Table 1: Data structure on the state of IA among students majoring in Computer Sciences.

Attributes	**Contents/Questions**	**Type**	**Statistics**
age	Age of the student	Numeric	Minimum 16 Maximum 59 Mean 19.756 StdDev 6.806
sex	Student's sex	Nominal	Female 199 Male 63
3	Can't imagine my life without the Internet	Nominal	yes 184 undefined 39 no 39
4	When I cannot use the Internet I feel anxiety, irritation	Nominal	yes 81 undefined 134 no 47
5	I like "surfing" the Net without a clearly defined purpose	Nominal	yes 121 undefined 112 no 29
6	I can give up from food, sleep, going to classes, if a have a chance to use the Internet for free	Nominal	yes 248 undefined 7 no 7
7	I prefer meeting new people over the Internet rather than in real life	Nominal	yes 185 undefined 37 no 40
8	I often feel that I've spent not enough time playing computer games over the Internet, I constantly wish to play longer	Nominal	yes 178 undefined 61 no 23

```
@relation answer_IA

@attribute age numeric
@attribute sex {female,male}
@attribute 3 {no,undefined,yes}
@attribute 4 {no,undefined,yes}
@attribute 5 {no,undefined,yes}
@attribute 6 {no,undefined,yes}
@attribute 7 {no,undefined,yes}
@attribute 8 {no,undefined,yes}

@data
18,male,yes,no,no,no,no,yes
28,male,undefined,no,no,no,no,yes
20,female,yes,yes,yes,no,no,no
22,male,yes,no,no,no,no,no
...
```

Figure 1: Data set on the state of IA among students majoring in Computer Sciences, presented in the ARFF format.

tion. This approach is based on the following presuppositions: objects that have a certain number of similar (different) features group in one segment (cluster). The level of similarity (difference) between the objects that belong to one segment (cluster) must be higher than the level of their similarity with the objects that belong to other segments (Klochko, 2019).

Let us look at one of cluster analysis algorithms (Klochko, 2019).

Output matrix:

$$X = \begin{pmatrix} x_{11} & \dots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \dots & x_{mn} \end{pmatrix}.$$

Let us move to the matrix of standardized Z values with elements:

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j};$$

where $j = 1, 2, \cdots, n$ — index number, $i = 1, 2, \cdots, m$ – observation number;

$$\bar{x}_j = \frac{1}{m} \sum_{i=1}^{m} x_{ij};$$

$$s_j = \sqrt{\frac{1}{m} \sum_{i=1}^{m} (x_{ij} - \bar{x}_j)^2} = \sqrt{(\overline{x_{ij}^2}) - (\bar{x}_j)^2}.$$

There are several ways to define the distance between two observations z_i and z_v: weighted Euclidean distance, which is determined by the formula

$$\rho_{BE}(z_i, z_v) = \sqrt{\sum_{l=1}^{n} w_l (z_{il} - z_{vl})^2},$$

where w_l is the "weight" of index; $0 < w_l \leq 1$; if $w_l = 1$ for all $l = 1, 2, \ldots, n$, then we get the usual Euclidean distance

$$\rho_{BE}(z_i, z_v) = \sqrt{\sum_{l=1}^{n} (z_{il} - z_{vl})^2}.$$

Hamming distance:

$$\rho_{BH}(z_i, z_v) = \sum_{l=1}^{n} |z_{il} - z_{vl}|,$$

in most cases this way of distance measuring gives the same result as the usual Euclidean distance, but in this case the influence of non-systemic large differences (runouts) decreases.

Chebyshev distance:

$$\rho_{BCH}(z_i, z_v) = max_{1 \leq l \leq n} |z_{il} - z_{vl}|,$$

it is best to apply this distance in order to determine the differences existing between the two objects using only one dimension.

Mahalanobis distance:

$$\rho_{BM}(z_i, z_v) = \sqrt{(z_i - z_v)^T S^{-1} (z_i - z_v)},$$

where S is covariance matrix; this distance measurement gives good results when applied to a concrete data group, but it does not work very well, if the covariance matrix is calculated for the whole data set.

Distance between peaks:

$$\rho_{BL}(z_i, z_v) = \frac{1}{n} \sum_{l=1}^{n} \frac{|z_{il} - z_{vl}|}{z_{il} + z_{vl}},$$

presupposes independence of random variables, which indicates the distance in the orthogonal space.

It is best to choose from the above described distance measures after the consideration of the structure and characteristics of the data sample.

Let us present the received measurements in the form of distance matrix:

$$R = \begin{pmatrix} 0 & \rho_{12} & \rho_{13} & \cdots & \rho_{1m} \\ \rho_{21} & 0 & \rho_{23} & \cdots & \rho_{2m} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \rho_{i1} & \rho_{i2} & \rho_{i3} & \cdots & \rho_{im} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \rho_{m1} & \rho_{m2} & \rho_{m3} & \cdots & 0 \end{pmatrix}.$$

As the R matrix is symmetric, i.e. $\rho_{iv} = \rho_{vi}$, we may confine ourselves to off-diagonal matrix elements. Using the distance matrix, we can implement the agglomerative hierarchic procedure of cluster analysis. Distances between clusters are determined as the closest or the farthest ones. In the first case, the distance between the clusters is the one between the closest elements of these clusters, in the second case, it is the one between the two farthermost located. The principle of the work of agglomerative hierarchic procedures lies in a consequent grouping of elements, starting from the ones closest to each other and those that are farther and farther apart. During the first step of the algorithm, every observation z_i ($i = 1, 2, ..., m$) is viewed as a separate cluster. Then, during every next step of the work of the algorithm, two closest located clusters are grouped together and then once again the distance matrix is built, but its dimension decreases by one. The algorithm stops its work when all the observations are grouped into clusters.

Let us look at the algorithms we used while clustering the data set regarding the state of IA disorder among students majoring in Computer Sciences:

EM (Expectation Maximization):

Determines the probability distribution for every object, which indicated its belongingness to each cluster. EM methods (Keng, 2016): Maximum Likelihood Estimation (MLE) or Maximum a Posteriori (MAP). Description of the algorithm is shown in figure 2 (Keng, 2016): at the E-stage (expectation) we calculate the estimated likelihood; at the M-stage (Maximization) we calculate the maximum likelihood estimation, increasing the expected likelihood, calculated at the E-stage; its value is used for the E-stage at the next iteration. The algorithm is repeated until its convergence.

K-Means algorithm:

Aims to partition n observations into k clusters in such a way that each observation belongs to the cluster with the nearest mean value. The shortest distance between the observations and the nearest mean value may be calculated by minimizing the sum of squares of the distances (Linoff and Berry, 2011) (figure 3).

Farthest First algorithm:

This is a modification of a K-Means algorithm, in which the initial selection of centroids is 2 and higher. Centroids are determined following the remoteness principle, i.e. the point farthest from the rest is selected first. The Farthest First algorithm is described in figure 4 (Dasgupta and Long, 2005).

During the second stage of the survey on the situation with IA among students of various specialties was conducted with the help of Google Forms. 363

0. **Initialization**: Get an initial estimate for parameters θ^0 (e.g. all the μ_k, σ_k^2, and π variables). In many cases, this can just be a random initialization.
1. **Expectation Step**: Assume the parameters (θ^{t-1}) from the previous step are fixed, compute the expected values of the latent variables (or more often a *function* of the expected values of the latent variables).
2. **Maximization Step**: Given the values you computed in the last step (essentially known values for the latent variables), estimate new values for θ^t that maximize a variant of the likelihood function.
3. **Exit Condition**: If likelihood of the observations have not changed much, exit; otherwise, go back to Step 1.

Figure 2: Description of how the algorithm EM works from 10,000 feet (Keng, 2016).

Require: c – number of clusters
  Initialization: Randomly select c points
    that will be cluster centroids for first iteration.
  repeat
    Assign each observation from the to the cluster
    with the nearest centroid. Recalculate cluster centroids
    taking into consideration the current observation distribution.
  until Until the structure stabilizes or the condition for stopping
    the algorithm is fulfilled (e.g. maximal number of iterations)

Figure 3: K-Means algorithm (Linoff and Berry, 2011).

students from different regions of Ukraine took part in the survey. The data set is presented in the ARFF format and consists of 9 attributes (figure 5). The data set contains the fields described in table 2.

Cluster analysis is one of the tasks of database mining. Cluster analysis is a set of methods of multidimensional observations or objects classification, based on defining the concept of distance between the objects and their subsequent grouping (into clusters, taxons, classes). The selection of a concrete cluster analysis method depends on the purpose of classification (Klochko, 2019). At the same time, one does not need a priori information about the statistical population. This approach is based on the following presuppositions: objects that have a certain number of similar (different) features group in one segment (cluster). The level of similarity (difference) between the objects that belong to one segment (cluster) must be higher than the level of their similarity with the objects that belong to other segments (Klochko, 2019).

In order to analyze the IA phenomenon, we divide the respondents into three groups (Significant Risk (SR), Insignificant Risk (IR), No Risk (NR)). The division is based on the integrative use of qualitative and quantitative characteristics of the IA phenomenon. The SR group is formed on the basis of detecting and analysis of those IA features, which signify qualitative changes of the psychological status of a personality. The selection of such features is carries out on the basis of traditional understanding of the fact that in-depth psychic changes related to the formation of addictive behavior concern, primarily, vital (Balatskiy, 2008) and existential "foundations" of a personality. Such vital and existential (ontological) "foundations" are relatively stable and are subject to "external" transformation if the influence is significant and long-lasting. The changes concern the existential dimension (Frankl, 1985), vital resources (Balatskiy, 2008) and intentions as well as attitudes and behavioral stereotypes aimed at survival and life preservation. They are linked with the vital "foundations" of life itself.

The questions which reflect the above stated life "foundations" or vital resources are (table 2): "I can give up food, sleep, going to classes, if I have a chance to use the Internet for free" (1^{st} SR) and "When I cannot use the Internet, I feel anxiety, irritation" (2^{nd} SR). The 1^{st} SR seems to be more important as food and sleep are system organizing and basic vital needs. The ability to give them up indicates not only the "total", in-depth and comprehensive change of the hierarchy of vital needs, values and senses (Frankl, 1985;

Input: n data points with a distance metric $d(\cdot,\cdot)$.

Pick a point and label it 1.

For $i = 2, 3, \ldots, n$

Find the point furthest from $\{1, 2, \ldots, i-1\}$ and label it i.
Let $\pi(i) = \arg\min_{j<i} d(i, j)$.
Let $R_i = d(i, \pi(i))$.

Figure 4: Farthest-first traversal of a data set (Dasgupta and Long, 2005). Take the distance from a point x to a set S to be $d(x,S) = min_{y \in S} d(x,y)$ (Dasgupta and Long, 2005).

```
@relation answer_363_IA

@attribute age numeric
@attribute sex {female,male}
@attribute 3 {no,undefined,yes}
@attribute 4 {no,undefined,yes}
@attribute 5 {no,undefined,yes}
@attribute 6 {no,undefined,yes}
@attribute 7 {no,undefined,yes}
@attribute 8 {no,undefined,yes}
@attribute IA {nr,ir,sr}

@data
19,female,yes,yes,yes,no,no,no,sr
24,male,yes,yes,no,no,undefined,undefined,sr
26,female,no,no,no,no,no,no,nr
19,male,yes,no,no,no,yes,yes,ir
...
```

Figure 5: Data set on the state of IA of students, presented in the ARFF format.

Leontyev, 2017), but also the deformation of very vital "foundation" of a personality. The stated issues of food and sleep indirectly reflect the existential problems of a person. The is caused by the fact these issues concern the existential problem of "life and death" and the "I am" existential phenomenon. That is why, while IA is being formed, the existential problem is also being developed, which is temporarily and compensatory solved with a "potential possibility of Internet access".

In the first (1^{st} SR) question, the "can give up classes" part is an important social and personality oriented aspect. If the answer is positive, that means that the content embedded in the afore mentioned fragment is ignored and desemantized. This discloses the presence of desemantization and depreciation of the possible socio-economically "settled" future and a conscious self-limitation in the field of self-actualization in studying and professional activity. Another relevant point is ignoring communication, social ties, possibilities for self-improvement and "construction" of self in the educational discourse. The stated needs and aims are partially changed and substituted by the Internet. At the same time the "real" reality is replaced, deactualized and desemantized. The second (2^{nd} SR) question reflects the presence of neurotic anxiety, which is a manifestation of "exhaustion" and "overstrain" of the nervous system as well as of certain changes in the system of emotions and volition. Moreover, in this case, the problem of sense formation and understanding occurs as well as the corresponding changes in the value-conceptual field. This is what V. Frankl (Frankl, 1985) described and logoneurosis – the loss and / or absence of sublime and vital senses. The presence of a neurotic aspect in the form of neurotic anxiety is particularized through actualization in the 2^{nd} SR question of the irritation phenomenon ("... feel ... irritation").

In general, the 2^{nd} SR question supplements, particularizes and "strengthens" the deficit and "narrowing" of vitality, life creativity, nature corresponding existence, healthy life preservation instinct (food, sleep, communication). The stated vital resources and life creativity, which are actualized and problematized in the 1^{st} SR and 2^{nd} SR question, act as a complex diagnostic sub-system. It is aimed at detecting systemic, comprehensive stable, in-depth, vital, personal-psychological problems (i.e. disorders). The stated problems may develop and together transform into AI.

The 1^{st} SR and 2^{nd} SR questions, which reflect the vitality pf a person and his/her existence, disclose the qualitative difference of the SR group from IR and NR groups, which do not have the stated peculiarities. Thus, with a certain degree of certainty, the SR group may be represented as well as diagnosed with a relatively limited number of questions (1^{st} SR and 2^{nd} SR). The questions, which represent the SR group indicate that the Internet has "penetrated" deep into the consciousness and into the core of a personality, in his/her vitality, into human existence (figure 6).

Table 2: Data structure on the state of IA of students.

Attributes	Contents/Questions	Type	Statistics
age	Age of the student	Numeric	Minimum 15 Maximum 59 Mean 20.306 StdDev 7.238
sex	Student's sex	Nominal	Female 260 Male 103
3	Can't imagine my life without the Internet	Nominal	yes 245 undefined 53 no 65
4	When I cannot use the Internet I feel anxiety, irritation	Nominal	yes 110 undefined 194 no 59
5	I like "surfing" the Net without a clearly defined purpose	Nominal	yes 169 undefined 156 no 38
6	I can give up from food, sleep, going to classes, if a have a chance to use the Internet for free	Nominal	yes 343 undefined 8 no 12
7	I prefer meeting new people over the Internet rather than in real life	Nominal	yes 263 undefined 48 no 520
8	I often feel that I've spent not enough time playing computer games over the Internet, I constantly wish to play longer	Nominal	yes 243 undefined 86 no 343
IA	IA disorder	Nominal	nr 113 ir 217 sr 33

Thus, the SR group is qualitatively different from IR and NR. The SR group represents either a considerable risk of IA development or a transitive (premorbid) state or even the presence of the actual IA pathology whereas the IR and NR groups indicate a greater or lesser possibility of its development.

The IR group is diagnosed by questions 3, 5, 7 and 8 of table 2, which reflect "weak" signs. The signs reflected in these questions are not attributive or essential. Accordingly, they do not represent the in-depth personality-psychological, vital and existential aspect of IA. That is why, these questions, by summing up a certain number of them (in this case, three), may form a certain degree of probability for having IA risks. These questions get a certain level of "consistency" when there is a certain number of them, in this case, not less than three.

Thus, the IR group is characterized (diagnosed) by the presence of three questions out of questions 3 (1^{st} IR), 5 (2^{nd} IR), 7 (3^{rd} IR) and 8 (4^{th} IR) of table 2. The 1^{st} IR question discloses contemporary reality of professional activity and communication, in which the Internet component id relevant, systemic, environmental and significant. Thus, taking into consideration current systemic Internet-oriented socio-technological and technological contexts, this question does not reveal the totality and explicitness of personality-psychological changes. It primarily indicates considerably high level or significance and even value of the Internet in the life of a person. The 2^{nd} IR question characterizes the peculiarity of the contemporary Internet-culture. It reflects the fact that the person has an actualized orientation-searching reflex and a corresponding search and cognitive behavior, and not just that possibility of IA development. While disclosing the peculiarities of modern-day Internet communication, the 3^{rd} IR question also partially characterizes the problem of the insufficiently developed communicative competence and communicative culture of a personality, which, in turn, is effectively compensated with Internet-communication.

As for the 4^{th} IR, the significant question is the one which indicates an integrative manifestation of the activity (leading aspect), cognitive, value-conceptual, creative and communicative dimensions of the psychic reality. The positive answer partially indicates

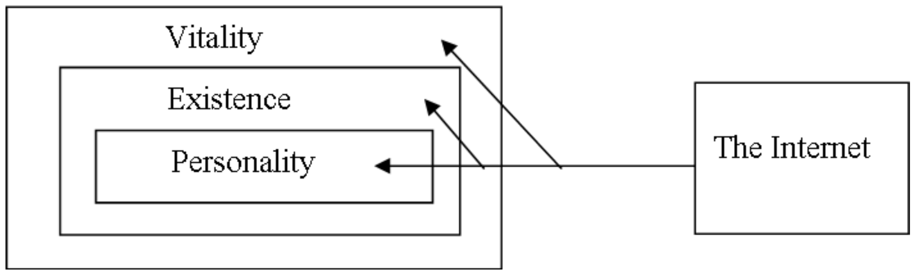

Figure 6: "Penetration" of the Internet into the core of a personality, into vitality, into existence, which illustrates the psychological mechanisms of risk formation in the SR group.

the presence of insufficient risks. At the same time, in its essence, a person is a creature that plays – Homo ludens (Huizinga, 2016). What is important, is the fact that at an early childhood a game is a specific integrative and integrating form of activity and the essence of human existence. The states gaming essence of a person can manifest itself in course of solving complicated tasks, studying as well as during leisure time. A computer game has a considerable mobilizing, emotional, orientation-search potential. A computer game can become addictive, both due to the "gaming" peculiarities of human nature and as a result of the professionally developed games that take human psychology into account. A computer game addiction thus indicates not only not as much the risks of IA development, but rather the presence of the "gaming essence" of Homo ludens. In addition, a considerable number of teenagers and grown-up develop computer game addiction as a consequence of the fact that they did not have a chance to fully realize their gaming potential in early childhood. This often happens due to intense early learning, which competes with gaming activity. The stated principle of competition between different forms of activity is described in Anokhin (Anokhin, 1968) study on functional systems (Sudakov, 2011). At the same time, constant interest in playing computer games poses a certain threat of the development of a computer game and Internet addictions as it "touches" different psychic spheres.

At the same time, if a person gives at least three positive answers to the 1^{st} IR, 2^{nd} IR, 3^{rd} IR and 4^{th} IR questions, this indicates a certain risk of IA development. This is caused by the fact that each question characterizes the influence of the Internet on a certain aspect of a personality: the 1^{st} IR – on the need and value-conceptual aspect, the 2^{nd} – on the cognitive aspect, including the orientation ability; the 3^{rd} – on the communicative aspect, the 4^{th} – on the activity component. Thus, actualization of the Internet as a need, value-conceptual, cognitive, communicative and activity phenomenon that is significant for a personality speaks of its certain "spread" and "rootedness" in the stated aspects (spheres) as well as about its corresponding significance and value. A certain "Internet locus" is formed in various spheres of a personality. Thus, as a result of systemic interiorization processes, the Internet "integrates" into a person's consciousness, becoming a significant phenomenon (figure 7). At the same time, the stated "integration" is "superficial", reversal, unstable, and such that does not lead to maladaptation or personality-psychological and behavioral changes.

The totality of the "spread" or "expansion" of the Internet on the psychic reality, as a significant phenomenon for several spheres of consciousness, creates certain (but considerably insignificant) risks of IA development. At the same time, the more spheres "contain" the "Internet locus", the higher the risks are as this means the increase of the number of opportunities for forming the summing up and synergy effects, which lead to qualitative changes.

NR is a group of questions, which characterize separate features of Internet influence. The personality demonstrates local, superficial, reactive reactions. That is why the people that fall into this group, the risks are almost absent or are rather insignificant.

The classification ensemble methods of machine learning were used to study the presence of IA disorder in students. The ensemble methods combine a few algorithms that learn simultaneously and compensate or correct mistakes of one another. Such approaches as stacking, bagging (bootstrap aggregating) and boosting are used while developing ensemble methods. Stacking used the approach of meta-learning in order to best combine a few machine learning models. On the basis of the basic-level models, the algorithm is taught. Using these results, the meta-model learns to better combine the predictions of basic models. Bagging uses multiple teaching of an ensemble of classifiers on random data sets, which is conducted simultaneously but independently from one another. Then, a determined averaging of results is conducted. The results are averaged on the basis of

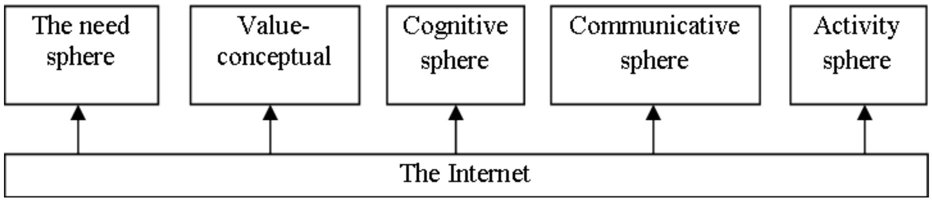

Figure 7: Influence of the Internet on various spheres of human psychic.

a determined strategy. Boosting carries out a consecutive adaptive algorithm teaching. The next algorithm learns through focusing on classification mistakes of the first algorithm. In this research, the authors used such ensemble classification algorithms as AdaBoost, Bagging, Random Forest and Vote.

The WEKA machine learning system uses the AdaBoost algorithm.M1 (figure 8) (Freund and Schapire, 1996; Santos and de Barros, 2020). The AdaBoost meta-algorithm improves the efficiency of basic learning algorithms by building their combination. It uses adaptive boosting, building every next classifier according to the instance that were badly classified by previous classifiers. Having determined a weak classifier in the cycle, AdaBoost re-assigns the weights, and at every iteration the weights of incorrectly classified instances increase. By testing classifiers in such a way, the AdaBoost algorithm selects a classifier that better identifies the instances.

The Bagging (bootstrap aggregation) meta-algorithm uses compositions of algorithms each of which learns independently from one another; to determine the final result, the process called voting is being implemented, as a result of which, the mistakes of the classifiers are compensated (Breiman, 1996; Tuysuzoglu and Birant, 2020) (figure 9).

According to Leo Breiman's definition, "a Random Forest is a classifier consisting of a collection of tree-structured classifiers $\{h(x,\Theta_k), k = 1, \dots\}$ where the $\{\Theta_k\}$ are independent identically distributed random vectors and each tree casts a unit vote for the most popular class at input x" (figure 10) (Breiman, 2001; Zhong et al., 2020).

The voting classifier combines different classifiers that learn and are assessed simultaneously (Kittler et al., 1998; Kuncheva, 2014). The final decision regarding the prediction is taken by a majority vote following two strategies. In hard voting (majority voting), the class label is predicted, which is determined by a majority of votes of every classifier (Kittler et al., 1998; Kuncheva, 2014). In soft voting, probability vectors for every predicted class (for all classifiers) are summed up and averaged and the class with the highest value is selected (Kittler et al., 1998; Kuncheva, 2014).

3 RESULTS AND DISCUSSION

To cluster data using the WEKA platform, we will use Weka.clusterers.EM, Weka.clusterers.SimpleKMeans and Weka.clusterers.FarthestFirst algorithms (Weka, 2021).

We check the application of clustering algorithms that can be assigned to two classes of clustering algorithms, i.e. distribution based (Expectation Maximization) and centroid-based (K-Means, Farthest First). Such selection is motivated by the fact these algorithms have long been used to cluster different types of data in many fields and are considered to be effective.

Dunn, DB, SD, CDbw and S_Dbw were selected as validity indices for testing (da Silva et al., 2019; Moshtaghi et al., 2019) (table 3). In the CDbw index the distance from the point to multitude set in the course of selecting cluster element can be calculated in different ways. In this study, we use the sum of distances of already existing "representatives" of the cluster to each cluster element to calculate this distance. The element, on which the maximum was reached, was selected as the next "representative" of the cluster.

If the data set has no cluster structure, then such situation is not determined with the help of validity metrics. While using K-Means and Farthest First (table 2) the numbers of clusters for the two algorithms that were selected as optimal by the majority of indices, can only nominally be defined as cluster structure. As the work of Expectation Maximization algorithm is based on determining the probability of evaluating maximum similarity, the indices calculated for this algorithm are more homogenous. The structure, which is characterized by a small number of clusters that also have to be compact and separable, is determined to be the best one. Judging by the results of evaluation of clustering using the validity indices, we may consider that k-Means and Farthest First algorithms are most likely to give worse clustering results than the Expectation Maximization algorithms.

To cluster the data, we select training/testing using the percentage split option. As a data set for training (model building) we select 66% of data from the set.

Input: sequence of m examples $\langle (x_1, y_1), \ldots, (x_m, y_m) \rangle$
with labels $y_i \in Y = \{1, \ldots, k\}$
weak learning algorithm **WeakLearn**
integer T specifying number of iterations

Initialize $D_1(i) = 1/m$ for all i.

Do for $t = 1, 2, \ldots, T$:

1. Call **WeakLearn**, providing it with the distribution D_t.
2. Get back a hypothesis $h_t : X \to Y$.
3. Calculate the error of h_t: $\epsilon_t = \sum_{i:h_t(x_i) \neq y_i} D_t(i)$.
   If $\epsilon_t > 1/2$, then set $T = t - 1$ and abort loop.
4. Set $\beta_t = \epsilon_t/(1 - \epsilon_t)$.
5. Update distribution D_t:
   $$D_{t+1}(i) = \frac{D_t(i)}{Z_t} \times \begin{cases} \beta_t & \text{if } h_t(x_i) = y_i \\ 1 & \text{otherwise} \end{cases}$$
   where Z_t is a normalization constant (chosen so that D_{t+1} will be a distribution).

Output the final hypothesis:

$$h_{fin}(x) = \arg\max_{y \in Y} \sum_{t:h_t(x)=y} \log \frac{1}{\beta_t}.$$

Figure 8: The algorithm AdaBoost.M1 (Freund and Schapire, 1996).

For Classification, use a training set **X**, Inducer **I** and the number of bootstrap samples **m** as input. Generate a classifier $\mathbf{F}_{bag}$ as output. $\mathbf{F}_{bag}$ is the bagged prediction, and $\mathbf{F}_1$(X), $\mathbf{F}_2$(X),…, $\mathbf{F}_b$(X) are the predictions from the individual base learners.

1. Create **m** new training sets $\mathbf{X}_i$, from **X** with replacement.
2. Classifier $\mathbf{F}_i$ is built from each set $\mathbf{X}_i$ using **I** to determine the classification of set $\mathbf{X}_i$.
3. Finally classifier $\mathbf{F}_{bag}$ is generated by using the previously created set of classifiers $\mathbf{F}_i$ on the original data set **X**, the classification predicted most often by the sub-classifiers $\mathbf{F}_i$ is the final classification. $\mathbf{F}_{bag} = \mathbf{F}_1(X) + \mathbf{F}_2(X) + \ldots + \mathbf{F}_b(X)$.

Figure 9: The algorithm Bagging (Breiman, 1996; Lee et al., 2020).

As a data set for testing we select 34% of data from the set. In addition, we select number of clusters "3" in algorithm settings.

We received the following results:

In the course of application of the EM clustering algorithm, according to the built clustering model based on the training data set, three clusters were determined, their characteristics are given in table 4.

Cluster 0 (63% of respondents): The average age of respondents in this cluster is 17. The group consists predominantly of women. The characteristic feature of the representatives of this group is that they are unable to imagine their life without the Internet. There are variations in the levels of anxiety and irritation, if there is no possibility to use the Internet. There are also varying opinions regarding the aimless use of the Internet. As for other attributes, disorders related to IA may be observed in the insignificant number of respondents, who belong to this cluster. The behavioural model of the representatives of this cluster demonstrated Internet centration in the psychic reality of a personality, which is accordingly reflected in their activity and behavior, other life interests as well as significance of everyday activities lose their importance. The stated tendencies are linked to IA.

Cluster 1 (13% of respondents): For the representatives of this group the average value of the age attribute is 36 and it varies greatly. This is the oldest age group if compared with other clusters. This group has the largest share of women. Representatives of this group, predominantly, cannot imagine their life without the Internet. Thus, according to the centroid

Step 1. Random samples from the given data set are generated.
Step 2. The algorithm constructs a decision tree for each sample, receives the prediction result for each decision tree.
Step 3. Voting for each forecasted result is conducted.

Figure 10: The algorithm Random Forest (Breiman, 2001).

Table 3: Optimal number of clusters, calculated with the help of quality indices.

Index	Algorithms		
	Expectation Maximization	**k-Means**	**Farthest First**
Dunn	3	6	6
DB	3	6	4
SD	3	3	3
CDbw	3	3	3
S_Dbw	3	5	4

Table 4: Model and evaluation on test split by EM algorithm.

Attributes	Indications	Clusters		
		0 (0,63) 112.1491	**1** (0,13) 24.7781	**2** (0,24) 44.0727
age	mean	17.4469	36.2459	19.2906
	std. dev.	1.5994	10.0785	2.243
sex	female	108.8714	16.0638	5.0648
	male	2.2778	7.7143	38.0079
3	no	22.7034	3.1864	10.1102
	undefined	16.0405	6.4026	4.5569
	yes	73.4052	15.1891	29.4057
4	no	54.392	13.8263	27.7817
	undefined	23.6012	5.1903	7.2085
	yes	34.156	5.7615	9.0825
5	no	45.3302	19.3167	26.3531
	undefined	15.1791	2.1415	5.6794
	yes	51.6398	3.32	12.0403
6	no	106.1573	22.7561	41.0866
	undefined	1.0117	1.0098	1.9785
	yes	4.9802	1.0122	1.0076
7	no	81.1224	20.5492	27.3284
	undefined	11.5501	2.168	11.282
	yes	19.4767	2.061	5.4624
8	no	89.4444	19.3333	9.2223
	undefined	7.2533	1.1937	9.553
	yes	15.4514	4.2512	25.2975

values of the attributes, we may diagnose IA related Internet centration in the psychic reality of a personality, which is accordingly reflected in their activity and behavior; other life interests as well as significance of everyday activities lose their importance. There are predominantly no other signs of IA related disorders.

Cluster 2 (24% of respondents): The probabilistic average of the age attribute among the representatives of this group is middle-aged in comparison with other groups and is 19. Male representatives significantly dominate in this group. Regarding the inability to imagine their life without the Internet, opinions differed, however, predominantly respondents believe they have this addiction. Judging by the values of attributes 4, 5, 6 and 7, the vast majority of this group's representatives declare that they do not have other signs of IA. However, the feeling of the lack of time spent playing computer games over the Internet, which was confirmed by the vast majority of respondents, is a warning signal that may signify the existence of IA related disorders. Thus, the characteristic feature of this group is that most of its representatives have IA related disorders such as: Internet centration in the psychic reality of a personality; behavioral impulse control disorders related to online gaming. These people are in the risk group for developing IA related disorders.

In the course of application of the Farthest First algorithm, according to the built clustering model based on the training data set, there have also been three clusters formed; their characteristics are given in table 5.

Table 5: Model and evaluation on test split by Farthest First algorithm.

Attributes	Clusters		
	0	**1**	**2**
age	16.0	22.0	20.0
sex	female	male	male
3	yes	undefined	yes
4	undefined	no	yes
5	no	yes	undefined
6	no	no	undefined
7	no	undefined	undefined
8	no	undefined	no

Cluster 0: Contains data instances of the youngest age group, whose age centroid attribute is 16. According to the value of the sex centroid attribute, the group is made up of mostly female data instances. The representatives of this group cannot imagine their life without the Internet, i.e. there is obvious Internet centration in the psychic reality of a personality. Respondents cannot clearly determine whether they feel either anxiety or irritation if they do not have the possibility to use the Internet. Judging by other attributes, data instances of this cluster do not have IA related disorders.

Cluster 1: This cluster contains data instances of an older age group, the age attribute centroid of which is 22. The value of the sex attribute centroid in this cluster is male. A characteristic feature of the cluster is undecidedness regarding the vital need to use the Internet, prevalence of Internet relations over actual real interactions, feeling the lack of time spent playing computer games over the Internet (attributes 3, 7, 8 equal undefined). The value of the yes centroid of attribute 5 shows inclination to use the Internet without a concrete purpose. To give an overall characteristic, this group has signs of IA, i.e. behavior control disorders related to Internet use.

Cluster 2: By the value of the age attribute centroid, 20, this cluster contains data instances of the middle age group if compared with other clusters. The sex attribute centroid in this cluster is male. The representatives of this cluster cannot imagine their life without the Internet and feel anxiety and irritation when they do not have the possibility to use the Internet. They are characterized by their undecidedness regarding the vital need to use the Internet; giving up other life interests and everyday activities for the sake of free Internet use; prevalence of online relations of real-life interactions (value of attributes 5, 6, 7 is undefined). Thus, the representatives of this cluster have signs of IA, the priority significance of the Internet and behavior control disorders, related to Internet use. Compared to other groups, they are in the risk group for developing IA related disorders.

In the course of application of the K-Means algorithm to the clustering model built on the basis of the training data set three clusters have also been formed, their characteristics are presented in table 6.

Cluster 0: Contains data instances of the youngest age group, whose age attribute centroid is about 18. According to the sex attribute centroid, mostly female data instances are present in the groups. The representatives of this group cannot clearly determine whether they have a vital need to use the Internet. As for other indices, respondents state absence of signs of IA related disorders.

Table 6: Model and evaluation on test split by K-Means algorithm.

Attributes	**Clusters**		
	0	**1**	**2**
age	18.4194	21.8605	20.9552
sex	female	male	female
3	undefined	yes	yes
4	no	no	no
5	no	no	no
6	no	no	no
7	no	no	no
8	no	yes	no

Cluster 1: This cluster contains data instances of the older age group, whose age attribute centroid is about 22. The value of the sex attribute centroid in this cluster is male. Characteristic features of data instances that belong to this cluster include the vital need to use the Internet, feeling the lack of time spent playing online computer games as well as the systemic need to play longer. The overall characteristic of this cluster is the presence of signs of IA, i.e. behavior control issues related to Internet use, namely, gaming Internet addiction. If compared with other cluster, they belong to the risk group that may develop IA related disorders.

Cluster 2: By the value of age attribute centroid, which is about 21 years, compared to other clusters, this cluster contains data instances of medium age group. The sex attribute centroid is female. The representatives of this cluster cannot imagine their life without the Internet. Judging by centroids of other characteristics, respondents of this cluster do not have Internet-related disorders. Thus, the representatives of this cluster have only IA signs associated with the utmost significance of the Internet.

The cluster distribution of test data in the course of application of the three algorithms – the Expectation Maximization, Farthest First and K-Means – using the built training models is presented in table 7. Thus, as it can be seen from the table, the algorithms have determined three data groups. Clusters were formed, which included 71:12:7, 67:4:19 and 33:15:42 data instances respectively. There is a cluster that has the largest number of data instances; a group, which has the least data instances (exceptions); a group that includes several times more data instances than the smallest group.

Figures 11, 12 and 13 present a graphic representation of clusters by age characteristic of data instances, which are built using the training data set and received in the course of implementation of the Expectation Maximization, the Farthest First and the K-Means algorithm respectively. As we can see, the

Table 7: Clustered Instances determined using Expectation Maximization, K-Means and Farthest First algorithms.

Attributes	Expectation Maximization		Farthest First algorithm		K-Means	
	Instances	%	Instances	%	Instances	%
0	67	74	71	79	33	37
1	4	4	12	13	15	17
2	19	21	7	8	42	47

formed clusters differ from each other by the age attribute. For instance, Cluster 0, which contains most data instances, contains instances of respondents of a younger age, if formed through the application of the Expectation Maximization algorithm (figure 11). On the other hand, the same cluster received through the implementation of the Farthest First algorithm, contains data instance of various age groups (figure 12). Also, a small number of data instances of various age groups is present in Cluster 2, received in the course of implementation of the K-Means algorithm (figure 13). Cluster 0 and Cluster 2 formed with the Expectation Maximization algorithm as well as Cluster 1 and Cluster 2 formed with the Farthest First algorithm contain homogeneous age groups, and Cluster 0 and Cluster 1, formed with K-Means algorithm.

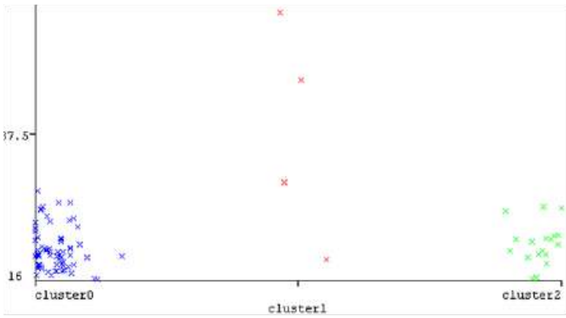

Figure 11: Plot of cluster distribution applying the Expectation Maximization algorithm depending on the age group attribute.

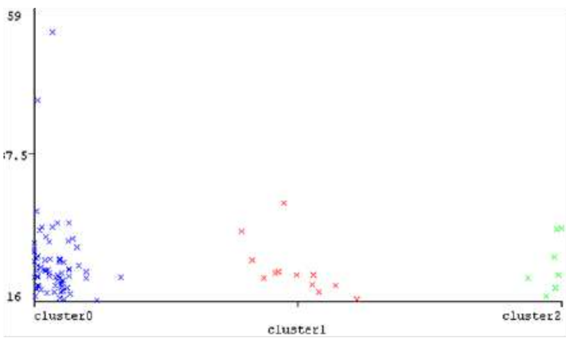

Figure 12: Plot of cluster distribution applying the Farthest First algorithm depending on the age group attribute.

Figures 14, 15 and 16 present a graphic representation by sex attribute of clusters formed through the application of the Expectation Maximization, Farthest First and K-Means algorithm respectively. The analysis of figure 14, which visualizes clustering through application of the Expectation Maximization algorithm, shows that Cluster 0 contains only female data instances. Clusters 1 and 2 have date instances of both sexes. Female data instances prevail in Cluster 1 and male ones in Cluster 2. Unlike Clusters formed by the Expectation Maximization algorithm, all the clusters formed by the Farthest First algorithm contain data instances of both sex groups (figure 15). Female data instances significantly prevail in Cluster 0. All the clusters built using the K-Means algorithm, contain both male and female data instances (figure 16).

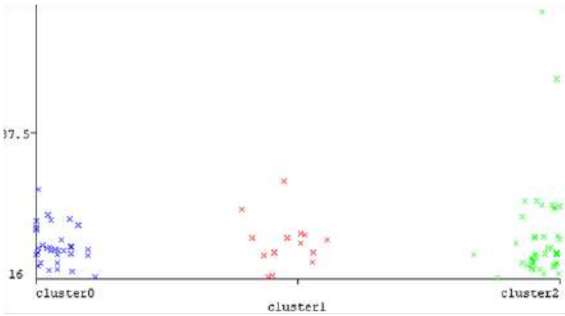

Figure 13: Plot of cluster distribution applying the K-Means algorithm depending on the age group attribute.

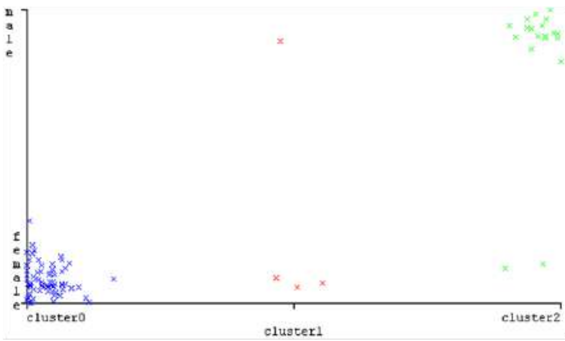

Figure 14: Plot of cluster distribution applying the Expectation Maximization algorithm depending on the sex attribute.

To classify a data set that contains 363 data sets, we break it with the help of random choice into a training set, which contains 70% (254) data sets and a test set, which contains 30% (109) data sets.

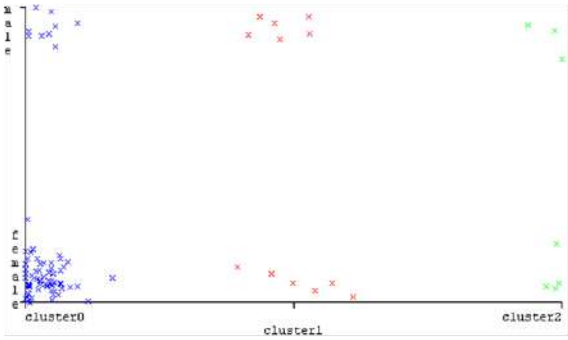

Figure 15: Plot of cluster distribution applying the Farthest First algorithm depending on the sex attribute.

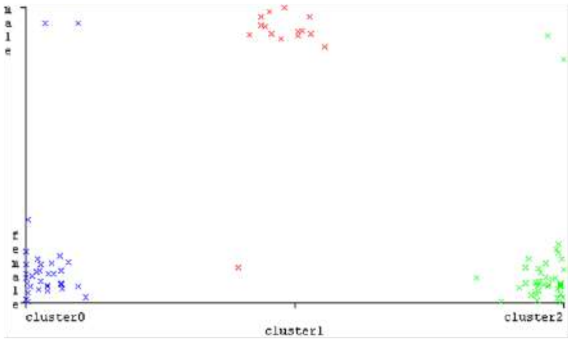

Figure 16: Plot of cluster distribution applying the K-Means algorithm depending on the sex attribute.

To classify using the WEKA machine learning system, we create classification models on the basis of the training set with the help of AdaBoost, Bagging, Random Forest and Vote algorithms.

The results are shown in tables 8, 9, 10, 11, 12, 13.

According to the results, that are reflected in tables 8-13, the highest percent of correctly classified instances both by the results of the training model as well as by the prediction results are received while applying the Bagging (classification algorithm classifiers.trees.REPTree) and Random Forest algorithms, with 94.4882% (testing – 96.3303%) and 96.8504% (testing – 99.0826%) respectively. In this case, overfitting is not observed as the stated models demonstrate a higher level of efficiency on test data rather than on training data. In addition, these models demonstrate the highest Kappa statistic and ROC Area indexes. At the same time, the best results are received while using the Random Forest algorithm. The results received in the course of application of the Ada Boost (classifiers.trees.DecisionStump) model are somewhat worse by all the criteria, but are still acceptable. According to the indexes provided in Tables 8 and 11, the worst results are received in the course of application of the Vote (classifiers.rules.ZeroR) model.

According to the Mean absolute error (MAE), the data forecast that is closes to the actual results both in the process pf learning as well as in the process of testing was built using the Random Forest 0.0597 (testing – 0.0405) and Bagging 0.0728 (testing – 0.0478) models; the worst result according to this indicator is received in the course of application of the Vote 0.3643 (testing – 0.3569) model. The approximately twice higher MAE value was received in course of building and testing the Ada Boost model, which is 0.1309 and 0.1029 respectively.

The Root mean squared error (RMSE) values also indicate the supremacy of the Random Forest 0.1391 (testing – 0.0964) and Bagging 0.1765 (testing – 0.1362) algorithms. The worst value was received as a result of building a model based on Vote 0.4263 (testing – 0.4176).

According to the Relative absolute error (RAE) and Root relative squared error (RRSE) the assessment prioritization of classification models is preserved with Random Forest and Bagging. It should be noted that the worst indexes are received as a result of classification using the M model (RAE=100%, RSE=100%), which characterizes an almost random prediction.

4 CONCLUSION

In the course of determine the fields of use and conduct an empirical comparison of ensemble classification and clustering methods using the WEKA machine learning system to study the signs of IA related disorders of students, the following conclusions have been made:

1. As a result of empirical comparison of Expectation Maximization, Farthest First and K-Means algorithms using the WEKA machine learning system, we developed models of data instances' clustering to determine the signs of internet addiction disorders among students majoring in Computer Sciences.
2. The implementation of the Expectation Maximization, the K-Means and the Farthest First algorithms each resulted in the formation of 3 clusters. The results of clustering demonstrate that Internet centration in the psychic reality of a personality is a characteristic feature of the respondents that took part in the survey. This also reflects accordingly in their activity and behavior, diminishing other life interests and the significance of everyday activities. In addition, in the course of implementation of the Expectation Maximization al-

Table 8: Evaluation of the results of the work of WEKA ensemble classification training models.

Ensemble classification algorithm scheme	**Correctly Classified Instances**	**Incorrectly Classified Instances**	**Kappa statistic**	**Mean absolute error**	**Root mean squared error**	**Relative absolute error**	**Root relative squared error**
weka.classifiers. meta.AdaBoostM1	224 (88.189%)	30 (11.811%)	0.7583	0.1309	0.2355	35.9359%	55.2562%
weka.classifiers. meta.Bagging	240 (94.4882%)	14 (5.5118%)	0.8962	0.0728	0.1765	19.9917%	41.3999%
weka.classifiers. trees.RandomForest	246 (96.8504%)	8 (3.1496%)	0.9411	0.0597	0.1391	16.375%	32.6236%
weka.classifiers. meta.Vote	152 (59.8425%)	102 (40.1575%)	0	0.3643	0.4263	100%	100%

Table 9: Detailed Accuracy by Class of the WEKA ensemble classification training models.

Ensemble classification algorithm scheme	**TP Rate**	**FP Rate**	**Precision**	**Recall**	**F-Measure**	**MCC**	**ROC Area**	**PRC**	**Area Class**
weka.classifiers. meta.AdaBoostM1	0.973	0.000	1.000	0.973	0.986	0.981	0.978	0.982	SR
	1.000	0.294	0.835	1.000	0.910	0.768	0.958	0.961	NR
	0.000	0.000	-	0.000	-	-	0.922	0.620	IR
Weighted Average	0.882	0.176	-	0.882	-	-	0.960	0.929	
weka.classifiers. meta.Bagging	0.973	0.000	1.000	0.973	0.986	0.981	0.975	0.981	SR
	0.980	0.108	0.931	0.980	0.955	0.886	0.972	0.965	NR
	0.679	0.013	0.864	0.679	0.760	0.741	0.975	0.852	IR
Weighted Average	0.945	0.066	0.944	0.945	0.943	0.898	0.974	0.957	
weka.classifiers. trees.Random Forest	0.973	0.000	1.000	0.973	0.986	0.981	0.998	0.996	SR
	0.993	0.069	0.956	0.993	0.974	0.935	0.994	0.995	NR
	0.821	0.004	0.958	0.821	0.885	0.875	0.995	0.971	IR
Weighted Average	0.969	0.042	0.969	0.969	0.968	0.942	0.995	0.993	
weka.classifiers. meta.Vote	0.000	0.000	-	0.000	-	-	0.484	0.285	SR
	1.000	1.000	0.598	1.000	0.749	-	0.475	0.586	NR
	0.000	0.000	-	0.000	-	-	0.466	0.103	IR
Weighted Average	0.598	0.598	-	0.598	-	-	0.477	0.445	

gorithm, a cluster was formed, whose representatives have behavior control disorders, related to online gaming. These respondents are in the risk group for developing IA related disorders.

3. Expectation Maximization, Farthest First and K-Means algorithms of data clustering differ by their algorithm model, however, from the point of characteristic features, they produce relatively similar clusters, thus implementing optimized clustering. At the same time, when a data set was grouped into three clusters by implementing these algorithms, the clusters differed by cluster model, namely, by the number of data instances in each cluster, their structure and value of attribute centroids.

4. Judging by the evaluation results of clustering validity using the validity indices, we can state that most likely the K-Means and Farthest First algorithms show worse clustering results than the Expectation Maximization algorithm.

5. Respondents are divided into three groups (Significant Risk (SR), Insignificant Risk (IR), No Risk (NR)). Such division gives the possibility of primary general assessment of risks of IA development based on the significance of Internet influence on the psychic of a person. The Significant Risk (SR) group is determined by asking questions, which reflect the signs of “in-depth”, maladaptive and, accordingly, a relatively long-lasting influence of the Internet on the psychic, vital resources, vitality, the existential level, the personality in general in its vital and conceptual basis. The Insignificant Risk (IR) is determined by asking question, which disclose the signs of “superficial”, local, adaptive even though a rather significant influence on the psychic. In this group

Table 10: Table of confusion matrix of WEKA ensemble classification testing models.

		Actual class			
	Ensemble classification algorithm scheme	**Area Class**	**SR**	**NR**	**IR**
Predicted class	weka.classifiers.meta.AdaBoostM1	SR	72	2	0
		NR	0	152	0
		IR	0	28	0
	weka.classifiers.meta.Bagging	SR	72	2	0
		NR	0	149	3
		IR	0	9	19
	weka.classifiers.trees.RandomForest	SR	72	2	0
		NR	0	151	1
		IR	0	5	23
	weka.classifiers.meta.Vote	0	74	0	
		NR	0	152	0
		IR	0	28	0

Table 11: Evaluation of the results of testing the WEKA ensemble classification models.

Ensemble classification algorithm scheme	**Correctly Classified Instances**	**Incorrectly Classified Instances**	**Kappa statistic**	**Mean absolute error**	**Root mean squared error**	**Relative absolute error**	**Root relative squared error**
weka.classifiers. meta.AdaBoostM1	103 (94.4954%)	6 (5.5046%)	0.8869	0.1029	0.1729	28.8318%	41.399%
weka.classifiers. meta.Bagging	105 (96.3303%)	4 (3.6697%)	0.9276	0.0478	0.1362	13.3815%	32.6122%
weka.classifiers. trees.RandomForest	108 (99.0826%)	1 (0.9174%)	0.982	0.0405	0.0964	11.3566%	23.0819%
weka.classifiers. meta.Vote	65 (59.633%)	44 (40.367%)	0	0.3569	0.4176	100%	100%

the spheres, influence by the Internet are the cognitive, activity, value-conceptual, need, communicative spheres of the psychic. The No Risk (NR) group indicates the absence of risks for IA development. Belongingness to this group is defined y asking questions, which reflect an insignificant, local and short-tern influence of the Internet on the psychic.

6. The model that gave the results that are the closest ones to the actual classification results is the model built using the Random Forest algorithm. According to all the assessments, the classification model built using the Bagging algorithm (classification algorithm classifiers.trees.REPTree) is close to it. Somewhat lower classification indexes are received in the course of building a model using the Ada Boost algorithm (classifiers.trees.DecisionStump). These models can be considered suitable for diagnosing IA disorders among students. The model built with the help of the Vote algorithm (classifiers.rules.ZeroR) is not suitable for use. Such a result indicates that the application of this algorithm requires additional modifications.
7. Intellectual analysis of the data set regarding the situation with IA among students majoring in Computer Sciences with the application of ensemble classification and clustering methods has shown that the methods studied above may be considered suitable for developing models for detecting IA disorders and respondent groups with the signs of IA related disorders.
8. The results of the research indicate the expedience of the application of the intellectual data analysis in medical research using the machine learning systems. The presented methods may serve as the basis for a strategic development of new vectors of medical data processing as well as decision-making in this field.

The present-day medicine needs non-standard approaches to intellectual data analysis, complex application of methods, their modification, application the ensemble of methods in order to be able to process large data sets in digital systems. Our conclusions may help to determine the signs of IA related disor-

Table 12: Detailed Accuracy by Class of testing the WEKA ensemble classification models.

Ensemble classification algorithm scheme	**TP Rate**	**FP Rate**	**Precision**	**Recall**	**F-Measure**	**MCC**	**ROC Area**	**PRC**	**Area Class**
weka.classifiers. meta.AdaBoostM1	0.974	0.000	1.000	0.974	0.987	0.980	0.983	0.984	SR
	1.000	0.136	0.915	1.000	0.956	0.889	0.976	0.971	NR
	0.000	0.000	-	0.000	-	-	0.946	0.540	IR
Weighted Average	0.945	0.081	-	0.945	-	-	0.977	0.956	
weka.classifiers. meta.Bagging	0.974	0.000	1.000	0.974	0.987	0.980	1.000	1.000	SR
	0.985	0.068	0.955	0.985	0.970	0.924	0.995	0.997	NR
	0.600	0.010	0.750	0.600	0.667	0.657	0.975	0.750	IR
Weighted Average	0.963	0.041	0.962	0.963	0.962	0.932	0.996	0.987	
weka.classifiers. trees.Random Forest	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	SR
	1.000	0.023	0.985	1.000	0.992	0.981	0.999	1.000	NR
	0.800	0.000	1.000	0.800	0.889	0.890	0.998	0.967	IR
Weighted Average	0.991	0.014	0.991	0.991	0.990	0.984	0.999	0.998	
weka.classifiers. meta.Vote	0.000	0.000	-	0.000	-	-	0.500	0.358	SR
	1.000	1.000	0.596	1.000	0.747	-	0.500	0.596	NR
	0.000	0.000	-	0.000	-	-	0.500	0.046	IR
Weighted Average	0.596	0.596	-	0.596	-	-	0.500	0.486	

Table 13: Table of confusion matrix of testing the WEKA ensemble classification models.

		Actual class			
	Ensemble classification algorithm scheme	**Area Class**	**SR**	**NR**	**IR**
Predicted class	weka.classifiers.meta.AdaBoostM1	SR	38	1	0
		NR	0	65	0
		IR	0	5	0
	weka.classifiers.meta.Bagging	SR	38	1	0
		NR	0	64	1
		IR	0	2	3
	weka.classifiers.trees.RandomForest	SR	39	0	0
		NR	0	65	0
		IR	0	1	4
	weka.classifiers.meta.Vote	0	39	0	
		NR	0	65	0
		IR	0	5	0

ders among students majoring in Computer Sciences, forecasting the risk of IA and development of services aimed at IA prevention.

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Theoretical Bases of Application of Free Software in Preparation of Pre-service Teachers of Mathematics, Physics and Computer Science

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Keywords: Free Software, Teacher Training, the Concept of Implementation.

Abstract: Modern development of education is associated with the use of information and communication technologies. To date, there is considerable experience in the use of computer training systems. New forms and methods of teaching based on modern information and communication technologies are being developed and used, the concept of e-education has appeared. In relation to free software, the period of systematization of the accumulated experience and its theoretical substantiation of application in educational activity has come. The proposed theoretical basis provided an opportunity to develop a system of free software in the training of pre-service teachers of Mathematics, Physics and Computer Science, which contains the conceptual, semantic, technological subsystem and subsystem of qualitative and quantitative indicators. The main purpose of the use of free software in the training of pre-service teachers of Mathematics, Physics and Computer Science is to increase the level of formation of information competence, which can not be fully formed without free software.

1 INTRODUCTION

At all stages of development and functioning of the education process its formation was carried out using certain methods, techniques and tools (Semerikov et al., 2021). The peculiarity of the current stage of development of education is that in the arsenal of techniques and tools used in the preparation of pre-service specialists are both traditional (printed) and digital (electronic) materials. Ensuring open around the clock, access of students to electronic education today is one of the priorities of information science, education and culture of Ukraine. In this regard, the role and functions of teachers are significantly changing. It should be noted that a special role in this process is played by information and communication technologies (ICT) as part of information-educational environment and include digital libraries, electronic educational resources, search engines and aggregation of information, which are based on the use of free software.

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2 RESEARCH QUESTION

Free software is the release of ideas of open scientific achievements in the field of computer science. It is because of this that free software has been developed in direct dependence on the academic environment. Despite its origin, it is not sufficiently represented in education due to a number of factors that constrain its spread (Velychko, 2016). Outsourcing has allowed to develop not only social networks and electronic resources, but also free software. Despite the fact that free software does not have marketing support for its distribution, its occasional use raises questions about its use in educational activities.

Today, various universities around the world are conducting research on the use of free software in educational activities. The results of application studies at Chu Hai College of Higher Education (Hong Kong, China) are presented by Duan and Lee (Duan and Lee, 2020). The largest free software project in education, involving 6 million students and 200,000 teachers each year in Kerala, India, is described in a study by Thankachan and Moore (Thankachan and Moore, 2017). An interesting review of the application of free and open source software is published by Gupta and Surbhi (Gupta and Surbhi, 2018). The pa-

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per presents not only analogues of application software but also training software. The authors conducted a study among Delhi teachers. This analysis gives an idea of the low prevalence of free and open source software and its causes.

Coca Bergolla and Pérez Pino (Coca Bergolla and Pérez Pino, 2021) offer free software to study artificial intelligence. To do this, the authors have developed a model of integration of educational free software to the educational process of studying artificial intelligence. The experiment allowed to draw a conclusion about the efficiency of the proposed model and the possibility of its application to the study of other sections of computer science. A similar study is described by Horvatić et al. (Horvatić et al., 2020) on the use of free and open source software in electrical engineering education.

For most information technology users who use free and open source software, the motivations of software developers are still unclear. The answer to the question of motivation to develop free and open source software is given by Daniel et al. (Daniel et al., 2020). Examining the internal and external motivations of the authors on the developers of free and open source software, the authors found those that promote the development of free and open source software and those that hinder its development. Another problem for free and open source software developers is outlined in Lee (Lee, 2018) work. The author explores the problem of involving volunteers in open projects and their short-term participation in projects.

Summing up, we present the conclusions of UNESCO on free software – ”model provides interesting tools and processes with which women and men can create, exchange, share and exploit software and knowledge efficiently and effectively. FOSS can play an important role as a practical instrument for development as its free and open aspirations make it a natural component of development efforts in the context of the Millennium Development Goals (MDGs)” (UNESCO, 2020).

3 RESULTS AND DISCUSSION

The content of the educational process in higher educational pedagogical institutions is determined by effective programs used to train pre-service specialists in that particular university. The content of the educational training of a university is being approved by the Council of the pedagogical university, while the choice of content, forms, means and methods of work is determined by the individual departments and teachers with consideration of specifics of each educational direction. Software products which are used and guidelines developed by university teachers taking into account specifics of preparation of pre-service teachers create the basic component of fundamental training. In the modern paradigm of education, it is necessary to develop educational standards which provide content of training upgrade as well as education of the younger generation on the principles of humanization, differentiation and integration.

The main *objective* of introducing of free software in the training of pre-service teacher of Mathematics, Physics and Computer Science lays in the formation of a new citizen of the information society, who feels comfortable in society, freely operates with information through ICT, respect the opinion of others and has his own opinion and knows how to deliver it, is capable of self-education, self-analysis and has a motivation to obtain new knowledge and to self-improvement, while also understands the importance and inevitability of information education and society at large, giving preference to the latest information and educational technologies. In this case it refers to the use of free software for the transition to a new type of training of pre-service of Mathematics, Physics and Computer Science, which includes:

- creation of optimal conditions for the acquisition of general and professional competencies and actualization of the intellectual potential of pre-service teachers of Mathematics, Physics and Computer Science;
- promoting comprehensive and harmonious development of pre-service teacher of Mathematics, Physics and Computer Science as subjects of education process and information society;
- creating suitable conditions for the emotional and intellectual enrichment of pre-service teacher of Mathematics, Physics and Computer Science as the basis of development and strengthening of political, social, economic, humanitarian, cultural and informational aspects of public life in the interest of the welfare of citizens, economic efficiency and country’s growth.

Strategy *aims* related to the use of free software in preparation of pre-service teacher of Mathematics, Physics and Computer Science need to be determined in accordance with the benefits that its implementation provides to the educational process, which, in our opinion, are:

- free access to software and its source code;
- safety, reliability and stability of the software;
- overcoming of the digital divide;

- open standards and independence from the developer;
- compliance with intellectual property rights, fight against piracy;
- ability to fully adapt to suit individual needs;
- unlimited number of simultaneous installations on multiple computers in educational institutions and at home;
- the ability to obtain derivative software products, use it in their own development;
- possibility of software localization.

To achieve these objectives, it is necessary to provide the following basic *measures*:

- analysis of didactic capabilities of free software through the procedure of examination and creating repositories of the recommended software provider;
- creating methodological, psychological and technological support for the use of free software in the preparation of pre-service teacher of Mathematics, Physics and Computer Science;
- analysis of readiness of subjects of the educational process for the use of free software;
- changing priorities as to the use of ICT in professional fields from studying certain software to studying technologies used to process information which in turn results in fundamentalization (see definition (Semerikov, 2009)) of the training of pre-service teacher of Mathematics, Physics and Computer Science).

Introduction of free software in the process of professional training of pre-service of Mathematics, Physics and Informatics is not an aim in itself – it is first of all a way of enhancing performance based on changing priorities of study and use of ICT in education. Currently, there is no single approach to the introduction of free software in the educational process; however, a considerable attention should be paid to implementing the following key principles.

The principle of reforming educational processes. The main prerequisite for the successful use of free software in the training of pre-service teachers of Mathematics, Physics and Computer Science is the understanding that these changes are not only in the analysis of its capabilities and in creating guidelines for such a process – primarily to create a new vision and new priorities for use of ICT. The use of free software, due to its openness and accessibility, expands the possibilities of using ICT anytime and anywhere. Such opportunities make it possible to create open information systems, without which it is impossible to obtain modern quality education and lifelong learning. The alternative of free software gives grounds to talk about its use as a means of solving problems, and not as an object of study – so the information and communication technologies, their mastery and use, and not the means of implementation come to the fore.

The principle of motivation to use free software. The use of free software, like any innovation, requires modern changes in the principles of learning and use of ICT in education. In order to include free software products in the list of software used in the professional training of pre-service teachers of Mathematics, Physics and Computer Science in higher pedagogical education, it is necessary to have both internal and external motivations for this process, based on the need for multifaceted and thorough training. pre-service teachers of Mathematics, Physics and Computer Science in the direction of awareness of information and communication technologies and an internal vision of their current state and the ability to analyze the constant updating of the information and communication technology industry. Motivation is the great impetus that will allow to gain direct support from the state and implement initiatives to use free software, adapting them to today's pedagogical tasks in the training of pre-service teachers of Mathematics, Physics and Computer Science.

The principle of strategic initiative. Taking into account the realities of austerity and taking into account the current needs of education, in particular the need to finance the training of pre-service teachers of Mathematics, Physics and Computer Science, we outline the main priority projects, which would be funded on a "protected" basis. Such projects should be characterized by a clear educational value, measured by certain criteria.

In terms of content, we are close to the position of UNESCO experts, who attributed it to strategic initiatives (UNESCO, 2014):

- introduction of information and communication technologies in the development of education, science and social knowledge (harmonization of general principles of building social knowledge; expanding learning opportunities through access to various content and delivery systems; improving research, dissemination of information and cultural exchanges; the use of ICT to build intellectual capacity, empowerment, governance and social participation);
- lifelong learning, including by means of distance education (expanding access of adults to higher education; organization of education near the place of residence; providing access to higher ed-

ucation by distance methods; reorganization of the learning process and structure of educational institutions taking into account the educational needs of adults);

- training of professional and pedagogical staff to work in a high-tech educational environment (expanding training opportunities for teachers through the use of technological means; improving the training process based on technological support in the form of appropriate programs and pilot projects that contribute to the successful implementation of educational tasks; popularization of ideas to ensure the quality of professional and pedagogical training of teachers, growth of a positive image of pedagogical professions).

The principle of cooperation. The need to introduce new forms of relationships both between the subjects of the educational process and in cooperation with the community of developers and users of free software. First, teachers must overcome their unwillingness to work with pre-service teachers of Mathematics, Physics and Computer Science to create and use e-learning resources based on open standards and free software. Overcoming such unpreparedness can occur through the introduction of educational disciplines in the educational process, the content of which is based on the study of the principles of development of electronic educational resources, rather than the acquisition of apathetic user skills. Second, cooperation in the development and application of free software will help the subjects of the educational process to carry out effective reforms, which will accelerate the process of practical application of free software in the training of pre-service teachers of Mathematics, Physics and Computer Science.

The principle of open systems. One approach to implementing this principle is to create an information and educational environment that contains software, hard-ware, communication mechanisms, interfaces, data formats and protocols that are based on available and generally accepted standards and that provide multi-platform, interoperability and scalability of applications and shared data. Software created for use in teaching and research should be as accessible as possible to scientists and educators. Information resources that can be extremely useful in teaching and research should also be as open as possible to their use. Another approach is to use functional standardization methods – building and using a profile, i.e. a coherent set of basic standards needed to solve a specific task or a whole class of tasks. The standard system (Open System Environment Reference Model – OSE / RM), adopted in the basic document ISO/IEC 14252, is used for standardization of open systems.

The general properties of open information systems can be formulated as follows:

- interaction (ability to interact with other application systems on local and (or) remote platforms (technical means on which the information system implemented by the network is implemented);
- standardization (information systems are designed and developed on the basis of agreed international standards and recommendations, the implementation of openness is carried out on the basis of functional standards in the field of information and communication technologies);
- extensibility / scalability (the ability to move applications and data in systems and environments that have different performance characteristics and different functionality, the ability to add new features to information systems);
- mobility / porting (providing the ability to transfer applications and data in the process of upgrading or replacing hardware platforms of information systems and the ability to work with them professionals who use information and communication technologies, without their special retraining when changing information systems);
- user-friendliness (developed unified interfaces in the processes of interaction in the system ”user – computer device – software”, which allow the user to work without special system training).

The principle of the rule of law, legality, equality of all subjects of the educational process before the law. The principle of the rule of law is based on the provision that not a person is subordinate to each other, but everyone follows the rules that determine, including the form of direct interpersonal relations – through a system of status-es or agreements. Such rule of law includes degrees of freedom of free software, copyleft (an antonym for copyright), and licensing agreements under which free software is distributed.

The principle of freedom of intellectual, creative activity. We define creativity as the ability of an individual that can be applied in any field of activity, whether production, social communications, scientific or research activities, and so on. Mental activity and achievements of mankind are key factors in the development of society. In countries where science, culture and art are respected, the standard of living is much higher, because the achievements of intellectual activity determine the level of development of production, culture, education and so on. We are convinced that in order to increase the level of development of society, the state must be interested in the development of science and education and, accordingly, comprehensively protect and support these areas of activity. In our opinion, such support includes direct budget financing, certain tax benefits, a system of incentives and support for investment in research and development, and so on. Note that a striking example of innovative mental activity is the development and creation of software in the case when the results of such activities are the subject of public use, have signs of openness and focus on increasing and improving the heritage of mankind. Such intellectual, creative activity meets universal needs and can be used in education.

The principle of social responsibility is a social phenomenon, which is a voluntary and conscious implementation, use and observance by the subjects of social relations, regulations, social norms both to the general doctrine of educational development and to the implementation of specific steps of its implementation. This principle is directly related to the informatization of education (Fedorenko et al., 2019). The process of using free software must comply with both legal and social norms, which is of particular importance in the educational process. Responsible attitude to the results of scientific, practical, creative and intellectual activities should be an important factor in the humanization of education and upbringing of a socially responsible member of society.

Defining the role and place of free software in the process of informatization of education, we note that the use of free software in the training of pre-service teachers of Mathematics, Physics and Computer Science at the current level of informatization of educational activities plays a special role in terms of forming a certain level of information culture and intellectual development. and in terms of forming a scientific worldview, understanding the essence of the practical orientation of computer science disciplines. At the same time, the level of such training in the future should enable pre-service teachers of Mathematics, Physics and Computer Science in the process of their professional activity to create and implement new technologies, even those whose theoretical basis may not yet be developed during training.

The main features of modern information society are: introduction of information to different spheres of life; concentration in the field of information and intellectual services of more than 40–50% of the population; development of general theory of information society; exponential growth of knowledge and accumulation of information; combining computer systems into a single information environment through means of communication; creating information in a digital code; extremely high development of production of technology and telecommunication technologies and means of communication requires a radical change in the field of education through information and adequate response to the demands of the information society.

According to the Law of Ukraine on the National Informatization Program, informatization means a series of interrelated organizational, legal, political, socioeconomic, scientific-technical, manufacturing processes aimed at creating conditions aiming to meet the information needs of citizens and society through the creation, development and use of information systems, networks, resources and information technology that are based on the use of modern computer and communications technology (Verkhovna Rada of Ukraine, 1998).

Computerization is driven by industry trends, including the informatization of education, by definition of Bykov (Bykov, 2010), is a set of interrelated organizational, legal, socio-economic, scientific-methodological, scientific, technical, manufacturing and administrative processes aimed at meeting information, computing and telecommunication needs of subjects of the educational process. Informatization of education is associated with a wide introduction of methods and means of ICT in educational system, the creation on this basis of computer-based information and communication environment, filling this environment with electronic research, education and management of information resources enabling entities to carry out the educational process, provide access to environmental resources, to use its tools and services for solving various problems.

Let's define the role and place of free software in the informatization of education. The use of free software in preparation at the present level of informatization of educational activity plays a special role in preparation of pre-service teacher of Mathematics, Physics and Computer Science in the formation of a certain level of informative culture and intellectual development as well as in the formation of a scientific outlook, understanding the essence of practical orientation of informatics disciplines. The level of this training should equip pre-service teacher and make them to be able to create and implement new technologies theoretical framework of which might yet not be developed while they are still in their training.

One of the steps of informatization of educational process, improving the quality of training of pre-service teachers of Mathematics, Physics and Computer Science, enhancing teaching and learning and scientific and research activities, the disclosure of creative potential, the increasing role of self-education, according to Zhaldak (Zhaldak, 2003), is the creation and widespread adoption into teaching practice of computer-oriented methodology of teaching based on the principles of progressive and not destructive embedding of ICT in active didactic systems, a harmonious combination of traditional and computer-oriented learning technologies, involving past achievements of pedagogical science of the past, improving and enhancing their achievements through the use of the achievements in development of computer technology and communications.

When looking at the methodological training system of A. M. Pyshkalo using a systematic approach to the understanding of teaching methods, where all components of the educational process form a single system with defined internal connections, who defined methodical system of education as a set of five hierarchically related components: learning objectives, contents, methods, tools and organizational learning, which form a single integrated functional structure focused on achieving the learning objectives (Zhaldak, 2003). The described methodical system is a condition for sustainable development, stability and control of the educational process, which is impossible for teaching disciplines of informatics cycle and in view of the role and place of self-education in the educational process (Ponomareva, 2021). Similar arguments are used by Morze (Morze, 2003). Considering the combination of methods, tools and organizational forms of traditional methodical teaching system all if which answer the question "how to teach?", Chernykh (Chernykh, 1995) that this is the formation of a unified system of subsystems, called technology of education. Based on this structure of subsystem, they determine target, contents and technological components of methodical system of training (Semerikov et al., 2021).

Society shapes the social demand to preparation of pre-service teacher and defines objectives of any educational discipline. Thus, the modern information society is characterized by high development and use of information technology and advanced technologies which guarantee the production of information resources and access to these, processes of automatization of all sectors of production and management. While formulating the learning objectives of any disciplines, particularly fundamental, characteristics and requirements of the information society must be taken into account. Learning objectives, according to Tryus (Tryus, 2010), is the initial condition for the creation of methodical system as the most specific and well-defined element of the system, that is, any modification of methodical system should, according to Morze (Morze, 2003), relate to the learning objectives which describes the basic principle of improvement of methodical system – commitment.

The implementation of the principle of purposefulness is possible only by defining and developing the specific content of the components of the methodological system, and vice versa, the development of content will make it possible to determine the purposefulness of the methodological system. When designing a methodological system in which free software is used as a learning tool, the main principles and main trends in the development of higher education should be taken into account. Such a system should become a basis for overcoming the shortcomings of the higher education system and promote the implementation of ways to overcome them, to meet the new educational paradigm in terms of using ICT to intensify the learning process. The system of free software in the training of pre-service teachers of Mathematics, Physics and Computer Science should be based on the modular principle of building curricula and programs of disciplines, apply innovative pedagogical learning technologies, widely use ICT, contain self-educational and research activities, use various methods and technologies training, apply effective organizational and pedagogical forms of training. The result of the development of the methodological system should be a methodological complex suitable for use in any form of education, as well as be a component of the information and educational environment of higher education.

The main tasks of using free software in the training of pre-service teachers of Mathematics, Physics and Computer Science are:

- demonstration of the essence of the scientific approach to the study of information processes and phenomena, the role of information and communication technologies in the development of scientific research and technical progress;
- mastering by pre-service teachers of mathematics, physics and informatics of methods of using information and communication technologies in professional activity, methods of selection and analysis of software capabilities;
- formation of skills of harmonious use of ICT in education and skills of independent processing of information and choice of appropriate technologies and means.

The use of free software in the preparation of pre-service teacher of Mathematics, Physics and Computer Science should ensure formation of individuality of pre-service teachers, develop their intellectual abilities, analytical and synthetic thinking, information culture, mastering information technologies necessary for professional basic training and professional work, mastering techniques of information technology based on free software necessary to analyze social, economic, technical, manufacturing and information systems, search for optimal solutions to improve the efficiency of the systems, ability to choose the best ways to implement these solutions, processing and analysis of experimental results.

The results of the introduction of free software in the process of professional training of pre-service teacher of Mathematics, Physics and Computer Science, in our view are:

- development of information culture of a person, computer literacy (due to a change in priorities from studying of certain software to studying information technologies and their implementation);
- development of content, methods and means of education to international standards (due to lack of legal and financial restrictions on access to sophisticated achievements in information technology field);
- reducing the term and improving the quality of education at all levels of training of personnel (through enabling the use of information technologies anywhere and at a convenient time);
- integration of academic, research and production activities (through access to the source code of software and means to change it according to individual needs);
- improving the management of education activities (through the use of open standards for interoperability) ;
- opportunity to intensify the training of pre-service teachers of Mathematics, Physics and Computer Science (through fundamentalization of professional training).

An important factor of the concept of implementation of free software in the professional training of pre-service teacher of Mathematics, Physics and Computer Science is compliance with international and national standards. In view of this, special attention should be paid to standards of electronic documents that must conform to the principles of openness and accessibility. These standards include international standards for open file formats, such as OASIS Open Document Format ODF 1.0 (ISO/IEC 26300) and Office Open XML (ISO/IEC 29500). Unfortunately, the national standard DSTU in this field does not exist, though, in our opinion, the existence of a national standard is needed to provide a framework of using open file formats.

The next step of standardization for Ukraine should be the definition of free software. This kind of standard was adopted in the Russian Federation (GOST R 54593-2011), which contains general provisions for free software and is based on international standard classification software (ISO/IEC TR 12182-2004) and processes life cycle software (ISO/IEC 12207:2016). Classification meets the standard of the types of programs and policy documents (GOST 19.101-77 operates in Ukraine) and the general requirements for policy documents (GOST 19.105-78 operates in Ukraine).

Describing the purpose, objectives, classification and criteria of free software, we note that free software is created and used to form a market where any information service, such as copying, duplication, modification, error correction, functionality, etc. can be sold and bought on a competitive market by free contract of two parties (supplier and buyer of the service) without appeal to a third party. This wording defines the general provisions of the licensed purity of free software in accordance with certain degrees of freedom. The specific tasks of free software include:

- ensuring import substitution of proprietary components of information systems, reducing dependence on monopolists, and, consequently, freedom of action in the Ukrainian information space;
- stimulating the development of the domestic industry of software development for computer systems;
- expanding the possibility of participation of domestic developers in the performance of works and provision of services for state, municipal needs and the needs of the private business sector;
- providing additional investment in the development of domestic producers;
- ensuring a high level of technological independence;
- reducing the number of violations related to the legal protection of software products for computer systems.

Based on the general criteria of freedom, which must meet the free software, we note that free software in the training of pre-service teachers of Mathematics, Physics and Computer Science should correlate with:

- the ability to freely use the software for any purposes not prohibited by applicable law;
- studying how the software product works and rework it for their own goals and needs;

- free distribution of copies of both original software products and modified versions;
- dissemination of own property and research results.

Drawing from these tasks, we believe that infrastructure of development and use of free software should include:

- isolated environment of software packages (means of obtaining the source code of software binary files are directly loaded onto computer systems) and other means of collective development;
- single repository of software for computer systems and source code for various hardware and software platforms including ready distributions of basic software application and standard software solutions;
- control system of software for computer systems, providing records and the right to use and reuse of software and their components;
- infrastructure support for users and developers;
- infrastructure implementation (application) of open standards and specifications, including automation assess of compliance with standards (specifications).

Expected outcomes of introduction of free software are, above all, in the transformation of educational technology, due to:

- transition from delivering already formed knowledge and its memorization to independent information search and constructing their own knowledge;
- joint training activities of pre-service teacher in different educational situations and simulating future professional situations;
- providing educational material in a nonlinear format;
- opportunity to study independently according to individual path and in his optimum pace;
- modeling of world processes and events during educational activities;
- revitalization of intellectual and emotional processes of perception, understanding, comprehension and interpretation of educational material through the integration of verbal, graphic and audiovisual information;
- satisfactory qualification of teachers and pre-service teachers in the field of information and communication technology (equal to the level of International / European Computer Driving License);
- satisfactory qualification of graduated in the field of information and communication technology;
- quality access for teachers and students to their own internal and external e-learning and teaching resources;
- quality access for teachers and senior students to scientific electronic resources;
- automated control of their own activities for teachers and students;
- use of wholly licensed software.

The result of preparing of pre-service teacher of Mathematics, Physics and Computer Science to be able to use free software in their own training will serve as their willingness to use free software in their own teaching careers.

The considered scientific and methodological approaches allowed us to develop a system of free software in the training of pre-service teachers of Mathematics, Physics and Computer Science (see figure 1).

We will describe the components of the created system of using free software in the training of pre-service teachers of Mathematics, Physics and Computer Science. The purpose, tasks, approaches and principles of functioning of the system of application of free software in preparation of pre-service teachers of Mathematics, Physics and Computer Science which make a conceptual subsystem of system are described. Therefore, we provide a detailed description of the components of the content subsystem.

The computer competence of pre-service teachers of Mathematics, Physics and Computer Science determines the content line of application of the free software system in their preparation and forms, accordingly, the content subsystem.

Given the activity nature of teaching, we have identified such components of information competence of preservice teachers of Mathematics, Physics and Computer Science, as:

- motivational and value (identification, understanding and updating of goals and objectives of their own educational activities; awareness of the importance of knowledge, skills and abilities in the use of free software in educational activities; focus on professional and pedagogical development and self-development);
- cognitive (possession of the content of theoretical, psychological and pedagogical, professional and methodological knowledge of the process of using free software in educational activities);

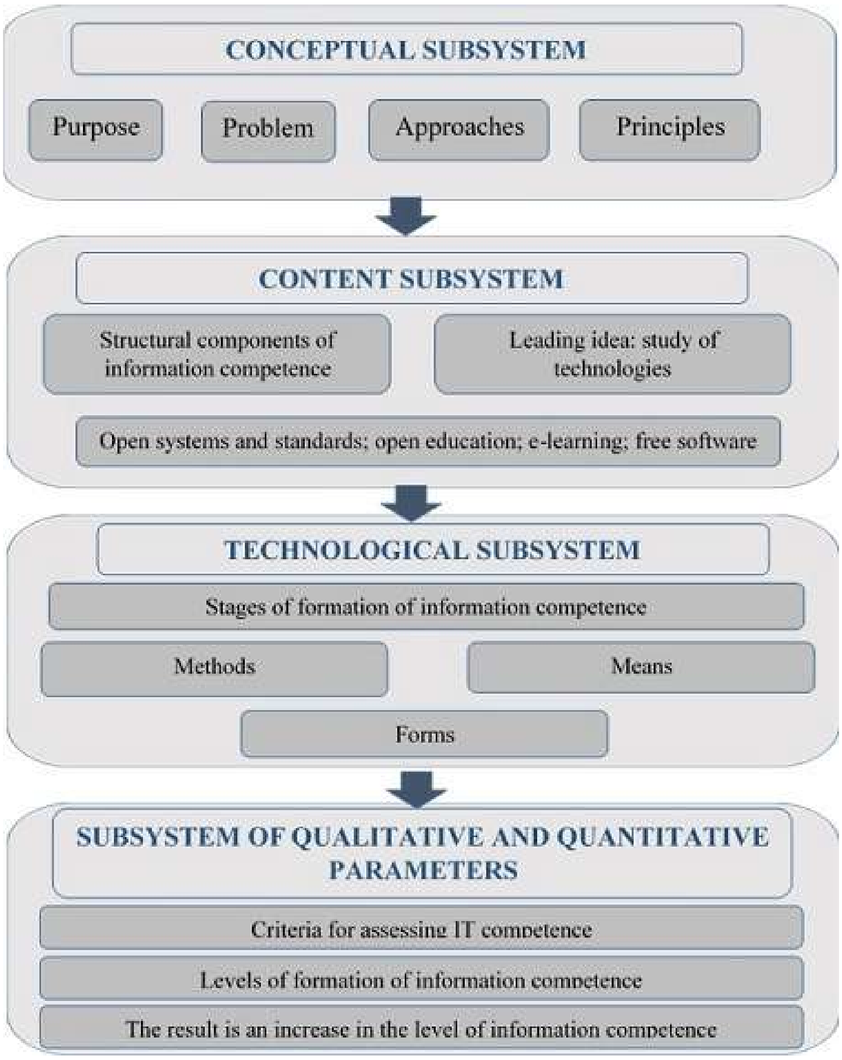

Figure 1: The system of using free software in the training of future teachers of Mathematics, Physics and Computer Science.

- activity (use of knowledge, skills and abilities in the process of studying both psychological and pedagogical and professional disciplines, and educational disciplines of the information cycle; choice of technologies, forms, methods, teaching aids, planning of educational tasks and their implementation);
- organizational and communicative (creation of own information and educational environment by means of free software; use of information and educational environment for professional communication, dissemination of pedagogical experience, professional activity);
- reflexive (control, self-control, evaluation, self-evaluation).

The content of the motivational and value component of information competence of pre-service teachers of Mathematics, Physics and Computer Science is their ability to solve issues related to the use of free software in professional activities. Motivational and value component is characterized by the formed need for systematic teaching and research activities, developed cognitive and exploratory motives, goal-setting skills, conscious desire and direction for intellectual self-development, readiness to meet educational needs, use of new methods and planning of self-educational activities. The effectiveness of training pre-service teachers of Mathematics, Physics and Computer Science to use free software in professional activities is impossible without a clear understanding of the need to take into account the didactic advantages and disadvantages of free software, creating favorable conditions for using free software to meet their educational needs in harmony with other teaching aids.

The cognitive component involves the presence of pre-service teachers of Mathematics, Physics and Computer Science knowledge about the nature and features of free software in their professional teaching activities, possible options for using free software in the classroom system, self-education, research activities; features of methods of teaching profile disciplines and involvement of information and communication technologies in educational activities; deep awareness of the importance of such functions as knowledge, skills, abilities and their improvement; ability to search and analyze the possibilities of free software in terms of its didactic direction; ability to learn and receive information; information and communication skills (planned and effective use of ICT tools for search and analysis); ability and willingness to work with free software.

The presence of pre-service teachers of Mathematics, Physics and Computer Science skills to use free software in professional activities and mastery of methods of organizing educational and cognitive activities determine the content of the activity component of training pre-service teachers of Mathematics, Physics and Computer Science to use free software. The presence of such a component in the structure of information competence allows to increase the professional potential of pre-service teachers of Mathematics, Physics and Computer Science, as the necessary skills and abilities to use free software can more effectively solve the problems of teaching, education and development.

In the context of our study, the activity component acts as a system of clear, understandable, purposeful actions of pre-service teachers of Mathematics, Physics and Computer Science, related to the planning and construction of educational activities and the organization of self-education.

The organizational and communicative component determines the ability of pre-service teachers of Mathematics, Physics and Computer Science to create their own information and educational environment by means of free software. The environment is created to meet personal needs for learning, training, aggregation of new knowledge, structuring existing knowledge. The created information and educational environment can be used in further professional activity after graduation from higher pedagogical education. The obtained structured and aggregated educational materials by means of information and communication technologies are distributed among those wishing to study with the purpose of their further use in future professional activity.

The reflexive component is a component that presupposes the presence of self-analysis and self-assessment skills; self-control and self-regulation; reflection skills (analysis of professional results, task planning to improve self-education); reflecting the attitude of students to the process and results of professional activity; ability to review and analyze one's own professional activity, distinguishing positive and negative components; compare the results with the planned tasks and consider ways to improve and verify them.

Thus, the information competence of pre-service teachers of Mathematics, Physics and Computer Science formed through the use of free software necessary for their own professional activities is the result of special training, which is a fundamental education of pre-service teachers of Mathematics, Physics and Computer Science, professional knowledge, skills, pedagogical experience and reflection; meets the requirements for professional pedagogical activity. The integrity of this education is determined by the full development of motivational-value, cognitive, activity, organizational-communicative and reflective components, the core of which is the conscious actions of pre-service teachers of Mathematics, Physics and Computer Science with mandatory use of free software in their professional activities.

4 CONCLUSIONS

The proposed conceptual basis is an open system enabled by its interaction with the environment (social order, standard of professional education, etc.) and integration of knowledge of pre-service teacher of Mathematics, Physics and Computer Science in such scientific fields as philosophy, psychology, pedagogy, theory and methods of teaching mathematics, theory and methods of teaching physics; theory and methods of teaching information technology as well as fundamental disciplines in the field of preparation of Mathematics, Physics and Computer Science. Conceptual framework can be supplemented and extended depending on the conditions and characteristics of the operation and can be used in the preparation of pre-service teachers to design the educational process from various disciplines based on their specifics.

The proposed conceptual basis is an integrated system. Each structural element of the proposed principles of the system is its subsystem. This concept of integrity is ensured through:

- the presence of such properties and qualities which are not inherent in its structural elements;
- coherence and mutual dependence of all structural

elements of conceptual principles as structural and logical and functional links between them.

Structural and logical connection provided by relationships and relationships of structural elements with each other and with over-system (social demand, state educational standard of higher education in "Pedagogical Education"). Functional connections of structural elements are defined by concept of efficacy provide by the aggregate of the basic principles and conceptual provisions.

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The Problem of the Limitations of the Educational Model Experiment on Population Genetics and Its Solution

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Keywords: Population Genetics, Repeatability of the Experiment, Massiveness of the Experiment, Ideal Population, Hardy-Weinberg's Law.

Abstract: The difficulty of conducting an educational model experiment on population genetics is in meeting the requirements of mass and replication. The evolution of a model experiment to study the Hardy-Weinberg law according to the methods proposed by the authors is considered – from the use of material models and manual counting of alleles and genotypes to the transition to automatic random distribution of elements of the genotypic structure of the population and automatic calculation of the resulting indicators. The technique of fully automated modeling of the genetic structure of the population allows to increase the size of the model sample by orders of magnitude. When using the technique in group work of students, it becomes possible to demonstrate the essence and differences of technical and biological replication as requirements for organizing a biological experiment. The technique is currently developed to work only with very large ideal populations.

1 INTRODUCTION

The academic subject "Biology" is a didactically adapted system of scientific biological knowledge. In the natural sciences, and biology is undoubtedly one of them, experiment is one of the main methods of research (Nechypurenko et al., 2021). This is what makes it possible, on the basis of the various factual material obtained, to make broad generalizations, to proceed to the establishment of connections, patterns that allow deeper penetration into the essence of the phenomena under study. Much has already been said about the experiment in biological science, about its types, methods, requirements for organization, limitations and difficulties of application. A huge number of scientific works are devoted to the history of the experimental method in biology. However, we were and are interested at the moment in the experimental method from the point of view of the possibilities of its use in biological education. In addition, narrowing down the subject area of interest to us, it is worth noting that the model experiment occupies a special place in high school. This allows you to create models of real objects and prototype the processes that occur with them in reality. In previous works, the authors has covered some aspects of this issue (Komarova and Azaryan, 2018; Komarova and Starova, 2020).

Modern course of biology in high school is based on the fundamental theoretical generalizations of basic biological science – scientific theories and laws. Fundamental genetic laws, classically studied by high school students, are laws of heredity of Mendel. Given the trends of development of modern biological sciences, namely, the development of theoretical biology, the main issues which are problems of genetics, ecology, evolution, law of genetic equilibrium concentrations (the law of Hardy-Weinberg) is considered as a fundamental law, the disclosure of which to high school students is aimed at understanding by them of the mechanism of evolution in general. This law reveals the regularities of functioning of living at the population – species level, including time frames.

Students' mastering of the patterns of population genetics and associated evolutionary theory is one of the most complex issues in biology course in high school. Studies (Hammersmith and Mertens, 1990; Mertens, 1992; Moore, 1994; Maret and Rissing, 1998; Mukhopadhyay et al., 2014; Pongsophon et al., 2007) confirm this.

We have conducted a survey among 52 high school students to ascertain their level of knowledge

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about the essence of law of genetic equilibrium concentrations, its value for the understanding of the factors and directions of the evolutionary process.

The tasks were as following:

1. Specify the mathematical equation of the law of Hardy–Weinberg (multiple answers are allowed):
   (a) $p+q=1$;
   (b) $(p+q)^2=1$;
   (c) $p^2+2pq+q^2=1$;
   (d) $p^2+pq+q^2=1$;
   (e) $p+2pq+q=1$.
2. Specify an equation describing the genotypic structure of the population (multiple answers are allowed): (see the answers to the assignment 1).
3. Specify the equation describing allelic population structure: (see answers to the assignment 1).
4. What are the conditions of validity of the law of equilibrium gene concentrations. Students were asked to solve three problems for the application of the law of equilibrium of gene concentrations.

The results of the survey are presented in figures 1–3.

Conditions of validity of the law, according to the student, were as following: population sizes are large – 29% of respondents, mating occurs at random – 24%, new mutations do not occur – 18%, all genotypes are equally fertile – 12%, generations do not overlap – 12%, there is no exchange of genes with other populations – 18%, the genes are in the autosomes and not in sex chromosomes - 18%, individuals of different genotypes are equally viable – 12%.

The obtained results allow to formulate the following conclusions: students insufficiently understood the description of the essence of the law of Hardy-Weinberg with two equations, namely, the definition of allelic and genotype structure of the population; the students are confused about variables included in the equations; knowledge about the conditions of the law is fragmentary. None of the respondents began to address two of the proposed problems, three of the respondents solved the third task incorrectly.

The results of the survey suggest the presence of formalism in high school students' knowledge about the law of genetic equilibrium concentrations. Formal approach to training lies in the mechanical memorization of educational material without enough understanding of its content. The low level of development of knowledge about the law of genetic equilibrium concentrations is one of the reasons for the difficulties of the students in understanding of the evolutionary content for the understanding of population genetics and population human genetics in particular.

Simulation, particularly computer simulation is one of the most effective training methods for demonstrating to students of the essence of complex biological processes, including genetic and evolutionary processes in natural populations.

In the process of studying the topic of the display of experimental method at the level of school biological education, transformation of ideas about how it is possible to implement the experimentation with complex biological systems, including those inaccessible to the student for direct study, we initially started out from the following. An educational biological experiment should maximally meet the requirements that are put forward for scientific biological experimentation. These, in particular, are the reliability in essence, the rule of single difference, replication, mass nature. From the mid-XXth century, a lot of attention has been paid to the organization of a school biological experiment, moreover to its various types, differing both in the object of research (botanical, zoological, physiological tests, functional tests, etc.), and in the form of carrying out under the conditions of school laboratory, class (demonstrational, laboratorial, mental) (Binas et al., 1990; Voronin and Mash, 1983; Shamrai and Zadorozhnyi, 2003; Frolov, 2007; Brunovt et al., 1973; Bazykin, 1988; Borodin, 1987; Bulaeva, 1977; Sidorova, 2009). Regardless of the type and form of carrying out, all various types of educational biological experiment must meet the abovementioned requirements in order that the results obtained were maximum consistent.

The biggest difficulties in the educational process are caused by the observance of such requirements as replication and mass nature. In other words, to ensure the veracity of results, the educational experiment should be conducted several times using a sufficiently large number of objects.

It is difficult to implement both the first and the second condition in the educational process due to the following reasons:

- firstly, the temporal limitations of the educational process;
- secondly, due to the inaccessibility of objects for study in the required quantity;
- thirdly, in the principle of inaccessibility of some objects and processes for direct study, primarily due to their objective specificity: either too small (organic molecules, cells, viral particles), or too large (populations).

Let's turn our attention to these reasons, possible ways of their elimination.

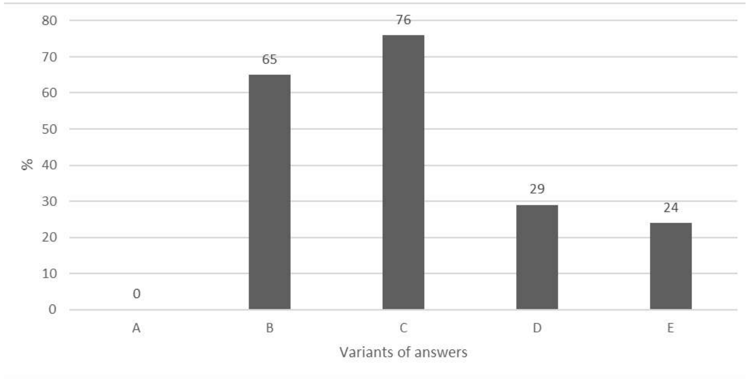


Figure 1: The results of the response to the first task.

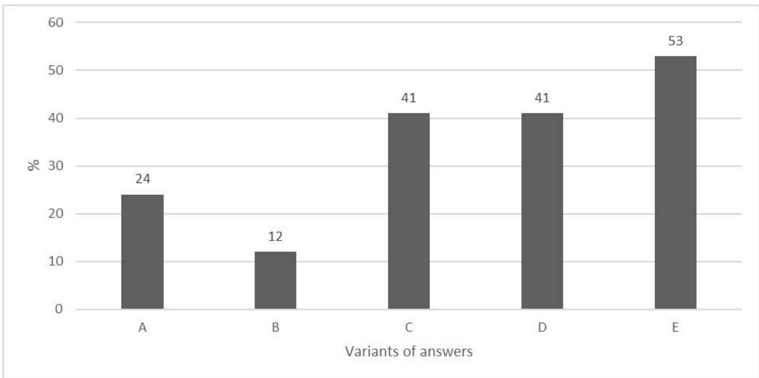


Figure 2: The results of the response to the second task.

Analysis of scientific literature in regards to the experimentation in biology showed that since the end of the 1980s, one of the actively discussed problems became the problem of pseudoreplication in ecological and biological research. In the classical variation, from the moment of publication of the first paper on this topic, pseudoreplication was considered as a negative experimental practice (Hurlbert, 1984). Even now, one of the criteria by which reviewers evaluate the submitted paper for a journal indexed in the authoritative international scientometric Scopus and Web of Science databases is the true and pseudoreplication of the experiments conducted (Brygadyrenko, 2017). Please note that at the moment the scientific community is still not so categorical in regards to pseudoreplication of experimental research. Discussions are being conducted on the issue of reality and contrivedness of the problem (Rosenberg, 2019; Kozlov and Hulbert, 2006; Rosenberg and Gelashvili, 2008).

We proceed from the assumption that the biology teaching methods cannot stay on the sidelines of the problems actively discussed in biological science. Moreover, this question lies in the plane of the science methodology. The mastery of methodological knowledge and the ability to apply them is the basis for the formation of a system of biological knowledge for senior high school students. The author's early works were devoted to this question (Komarova, 2017). So, we consider the question of to what extent in school experimentation in biology it is necessary to take into account the requirements that S. Hurlbert identified as the problem of pseudoreplication of experimental research in science, as definitively solvable in the direction of their observance. At the same time, given that the educational subject still differs from the basic science in that it is a didactically adapted version of it, it is necessary to achieve a double effect in organization of a school biological experiment. The first effect is that the results of the educational experiment should be maximum consistent, obtained by true replication. The second effect is that the use of true replication should be maximum ergonomical. Ergonomic in time, cost and complexity.

The purpose of this article is to demonstrate the capabilities of a school model experiment in studying

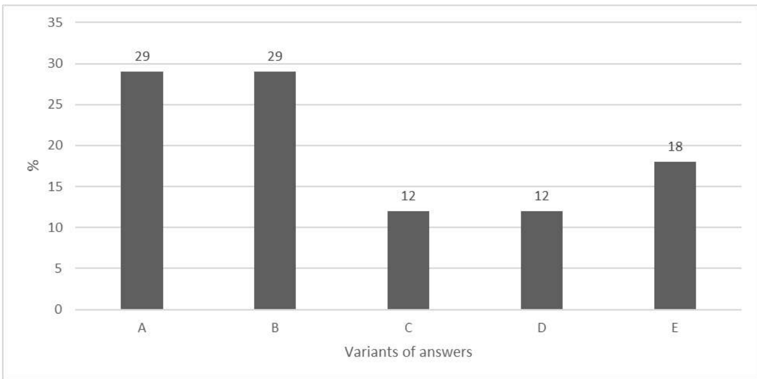


Figure 3: The results of the response to the third task.

the genetic structure of populations over time while meeting the requirements of technical and biological replication. Or, in another way, consider the possibilities of solving the problem of the limitations of an educational model experiment for the study of genetic evolutionary processes in populations.

2 TECHNIQUE AND METHODS

We consider it logical to state the essence of the declared problem in the sequence of answers to the following questions: what is the essence of replication in biological research? What is the essence of pseudoreplication in biological research, what is the history of the problem? How to ensure true replication in a model experiment by studying complex ideal and real biological objects in school biology (by the example of genetic structure of the population)?

Main issue. Why should we conduct at school a model experiment in study of the genetic structure of the population?

Study of the issue of model experimentation with the genetic structure of the population during 2015-2020 convinced us that its goal is the obtention by the students of a direct subject and mediated activity result. Subject result – 1) mastery of the essence of the law of genetic balance and the conditions under which it is consistent; 2) understanding of the mechanism of influence of evolutionary factors, such as natural selection, gene drift, gene flow, mutation process on the genetic structure of the population; understanding of the mechanisms forming the basis of micro- and macroevolutionary processes. The fundamental significance of the law of genetic equilibrium (Hardy-Weinberg) is that it is the central law of population genetics, it is based on the application of statistical methods in genetics (Dodge, 2008).

Before developing a methodology for a model experiment to study the genetic structure of a population, we posed two auxiliary questions:

1. Is it necessary to conduct a model experiment when studying the law of genetic equilibrium and the conditions for its consistency?
2. Can a model experiment be replaced with other educational methods?

The answer to the first question is: no, not necessarily. It is possible to limit to the demonstration of the multimedia presentation and video on this topic.

The answer to the second question is: yes, it is possible. An alternative is familiarization with theoretical material on a printed basis about the factors of change in the genetic structure of a population, overlearning of Hardy-Weinberg equations, teaching of the solution of problems on determination of the genetic structure of a population.

The answers to both questions demonstrate that in the alternative version, at the best, only one result will be achieved – a subject one. Without performing experimental actions, it is extremely difficult to form such elements of methodological knowledge as a variant of experience, replication, sampling. In addition, it has to be considered that the law of genetic equilibrium is a law, the substantial part of which consists of abstract categories not attached to a specific biological object (abstract homozygotes and heterozygotes, dominant and recessive alleles, conditions for the veracity of the law). And the law itself is applicable to some really non-existent ideal object, or, conversely, is not applicable to any really existing object (real population).

The abovementioned reasons are the answer for us to the main question, namely:

1) model experimentation contributes to the mastery by the students of abstract biological categories on concrete material objects;

2) allows to visualize the processes in an ideal population non-existent in reality;
3) allows to simulate the changes taking place in real populations over several generations. Thus, for educational purposes, the time frame of the actually occurring processes is condensed;
4) allows to vary the replications and variants of the experiment with minimal material costs;
5) allows to teach true replicates (replications) of the experimental impact;
6) allows to artificially quickly change the conditions (factors) affecting the population, including acting stochastically (Pavlotsky and Suslin, 1994).

What is the essence of replication in biological research?

A person possessing a basic level of biological knowledge within the scope of the school curriculum of complete secondary education, the term "replication" is known as a process related to the molecular level of organization of a living being. In the English-language scientific biological literature, the term "replication" is used not only in the meaning of the synthesis of new nucleotide sequences, but also in the meaning of the replicate of experimental attempts. In other words, the principle of replication in experiment is the well-known principle of replication. The last term is more widely used in domestic scientific works.

Replication in biological research can be technical and biological (Starmer, 2017).

Technical replicates give us these things:

1. They give us an accurate measurement they give this particular object.
2. If we want to tell more about this object or we do not want to generalize the data and transfer it to the population - a technical experiment is what we need.
3. They will also tell us how accurately we performed the measurements.
4. "If we wanted to publish a paper about how awesome our new method is, we'd use technical replicates" (Starmer, 2017).
5. If the experimental technique is transformed, different samples are taken simultaneously from one object, then technical replication will also take place, since they tell us about an individual.

In the biological replicates each measurement comes from different sample that comes from different objects.

Biological replicates give us these things:

1. Biological replicates tell us about a trait that occurs in a group. In biological replicates, each measurement comes from different samples or is obtained differently from one object.
2. You can mix biological and technical replicates, but the wisdom of doing this depends on the type of the experiment. Sometimes you get more bang for your buck if you add more biological replicates and ignore technical replicates.

   So, the difference between technical and biological replication is as follows: technical replicates are just repetition of the same experiment on the same person.
3. Biological replicates use different biological sources of samples (i.e. different people, different plants, and different cell lines) (Starmer, 2017).

When choosing the type of replication of a biological experiment, it is necessary to proceed from the purpose in view. If it is planned to describe a specific object, whether it be an individual, a population, or to research a method, it is necessary to use technical replication. If the goal is to study a group of objects, it is necessary to choose biological replication.

What is the history of the problem of pseudoreplication in biological research?

The problem of pseudoreplication was raised for the first time in 1984 by S. Hurlbert, who published a critical analysis of 156 experimental scientific papers in English-language editions published in 1960–1980s. He came to the conclusion that in 27% of cases there was one of two variants: 1) the experimental influence was applied in one replication; 2) the experimental replications were not statistically independent. Such errors were called pseudoreplication by S. Hurlbert. M. Kozlov notes that in Russian academic journals in 1998-2001 the part of papers based on pseudoreplication turned out to be twice as high (47%) than in the English-language periodicals for 1960-1980, i.e. before the publication of S. Hurlbert's paper. This situation was considered as non-normal, at the same time it was pointed out that the reason for the pseudoreplication lies not only in errors in experiment planning, but also in the incorrect application of statistical analysis to the results of a well-planned experiment (Kozlov, 2003).

After the publication of S. Hurlbert's paper in 1984 during the period from 1987 to 2001, according to M. Kozlov: 1) the term "pseudoreplication" firmly came into the ecological scientific lexicon of foreign authors, the problem of pseudoreplication in foreign ecological studies is actively discussed; 2) the number of foreign publications based on pseudoreplication began to decrease.

Back in 2003, M. Kozlov paid attention to the fact that the concept of pseudoreplication is completely unknown to the overwhelming majority of Russian ecologists. In addition, the author emphasized that S. Hurlbert's work was never cited in Russian-language periodicals, against the background of more than 2000 references (2015 references as of 2001) in English-language publications. M. Kozlov repeatedly published his works on standing up for the position that the problem of pseudoreplication is a problem of the world scientific community, which should be treated with all possible seriousness (Kozlov and Hulbert, 2006; Kozlov, 2003).

The English term "pseudoreplication" does not have a direct analogue in Russian, since it primarily denotes a process – an erroneous choice of replicates for assessment of intragroup variability in statistical analysis (Hurlbert, 1984; Kozlov and Hulbert, 2006). In this regard, direct translation of terminology is difficult enough; the authors provide English equivalents of key concepts. "In medical experiments, where they are designated to as "spurious replication", "trial inflation", or "the unit of analysis problem or error" (Whiting-O'Keefe et al., 1984; Andersen, 1990; Altman, Bland, 1997). Although the concept of "pseudoreplication", which is most adequately translated as "statistical analysis based on pseudoreplication", is not found in all works listed above, and we do not agree with all the conclusions of the indicated authors, all the cited studies are united by a serious approach to the problem" (Kozlov and Hulbert, 2006).

Is pseudoreplication as scary as it might seem?

In Russian-language sources, the attitude to the problem specified by S. Hurlbert and supported by M. Kozlov can be characterized as far-fetched and already well-known and studied (V. Nalimov, A. Lyubishchev, A. Bakanov, N. Plokhinskiy, T. Golikova). The Russian-speaking authors agree that there are two indisputable theses in the ideas of S. Hurlbert:

1) "it is not always correctly to extend the conclusions, obtained in the study of private samplings, to the entire general population;
2) assessment of the degree of factor influence may turn out to be erroneous if the studied effect is not properly localized, and the compared data are taken from insufficiently randomized sources" (Rosenberg and Gelashvili, 2008).

The conducted analysis of literary sources (Reinhart, 2015; Davies and Gray, 2015; Tatarnikov, 2005; V. Veličković, 2007; Hurlbert, 2004; Oksanen, 2004; Heffner et al., 1996) on the problem allowed us to single out the "pros" and "cons" of the consideration of the problem of pseudoreplication as significant for biological research. The analysis results are presented in table 1.

So, how to ensure replication in a model experiment on population genetics? How to overcome the limitations of the educational model experiment and comply with the conditions for obtaining reliable results?

3 RESULTS

3.1 The Results of the Theoretical Stage of the Study

The development of a model experiment methodology aimed at the study of the essence of genetic-evolutionary changes in the population by students, and its improvement during 2015–2020, was carried out by us in a staged manner. This was dictated by the objective and subjective difficulties of implementation of a model experiment into teaching practice.

At the first stage, we used only material models of gene alleles, created models of genotypes in a manual way, and, respectively, models of parental and daughter populations in generations. Mathematical calculations were performed without the use of a computer, the participants in the experiment manually calculated the frequencies of genotypes and alleles in populations, and presented the results obtained in the graphical representation.

At the second stage, we combined material modelling and use of the computer. Work with material models consisted of carrying out of the experiment itself, creation of a model of the parental population in manual way, and combination of the gene alleles at random (this is how panmixia was simulated). The participants entered the results of the experiments into a table on the developed web pages. With the help of a computer, the obtained frequencies of alleles and genotypes were automatically calculated. In automatic mode, the results of the experiment were optionally presented in the graphical representation.

We have developed a web page for entering, processing and presenting graphical view of modelling results of genetic and evolutionary processes in ideal populations, which are not influenced by the factors of changing its genetic structure (according to the law of Hardy-Weinberg) – http://mybio.education/mod/exp1/en/index.html (Model experiment 1. Study of the genetic structure of the ideal population) and http://mybio.education/mod/exp2/en/index.html (Model experiment 1. Study of the genetic structure of the ideal population (second option)), as well as web pages to make for entering the results of

Table 1: Pseudoreplication – a real problem in biological research.

“Pro” arguments	**“Con” arguments**
1. Each object in the sampling is a functional part of the whole, and not a separate element of a set. In a number of studies, the results and conclusions obtained for discrete objects apply to the entire population, which does not correspond to one of the requirements for biological experimentation – consistency in essence. 2. During the experiment, there is a multiple determination of reaction of the same organism in the course of sampled counts. As an alternative, the same sampling is studied in different time intervals. In this case, living objects (their populations) are pseudoreplications. 3. Two main problems of pseudoreplication is an insufficient mass nature of experimental objects and their initial incomparability with each other. In the first case, the researcher receives insufficient data for the consistent statistical result. In the second case, the problem has an objective causality due to the initial uniqueness of living objects.	1. Each object in the sampling is discrete and individual. 2. Factors acting independently on the sampling, act on a set of separate biological objects, and not on an integral object. The specificity of a biological experiment lies in the uniqueness of the objects and, in certain cases, in the impossibility of repeating the experiment in an accurate manner. 3. Living objects react to the actions of factors independently on a physical level, and thus they are statistically independent. In a majority of research variants, living objects are true replications. 4. The specificity of living objects in their uniqueness and originality. Some ecological research involves study of the reactions of individuals or parts to the impact. In a number of studies, it is not possible to repeat a unique biological object, whether it be an individual or a population. 5. The problem of pseudoreplication is artificial, since technical and biological replication is distinguished in biology. The attempt to apply the goals and requirements of technical replication to biological is a prime cause of the issue of pseudoreplication in biological experiments. 6. According to one of the points of view, the attention of English-speaking authors to the problem of pseudoreplication is explained by several reasons: • the desire to join the campaign of criticism and to incriminate colleagues in pseudoreplication; • the attempt to divert the stigma of pseudoreplication from their work and the work of colleagues; • as a warning signal to the reviewer that the author is acquainted with the work of S. Hurlbert, therefore there should be no comments on the paper (Rosenberg, 2019).

modelling of genetic and evolutionary processes in populations, which are influenced by the factors of changing its genetic structure http://mybio.education/mod/exp3/en/index.html (Model experiment 2. Study of the genetic structure of the population under the influence of natural selection), http://mybio.education/mod/exp4/en/index.html (Model experiment 3. Modelling the effect of gene flow on the genetic structure of the population), http://mybio.education/mod/exp5/en/index.html (Model experiment 4. Modelling the effect of random processes on the genetic structure of the population, modelling the drift of genes).

The system for on-line processing of modeling results developed in 2015 can be used only if the number of model individuals in the population is insignificant in the model experiment. The population size is limited by the objective possibility of creating a corresponding number of chip patterns of the alleles of a gene. Optimum number of chips – 100. In this case, the number of individuals is equal to 50. One can take more or fewer objects. In the first case, the choice will be associated with the growth of material costs for the manufacture of model elements. In the second case, the calculated values (allele frequency) will be significantly deviate from the pre-selected frequencies, and the level of statistical significance of the obtained results will decrease.

Stages of modelling of the genetic structure of populations are as following:

1. Modelling of the genetic structure of an ideal population with the use of material objects. Entry of simulation results into a table on web pages http://mybio.education/mod/exp1/en/index.html or http://mybio.education/mod/exp2/en/index.html.

Modelling of the genetic structure of an ideal population can be done using the possibilities of any of the two web pages. The difference between them lies in the methods of processing of the experimental results, namely in the methods of calculating the frequencies of genes. In the first variant, the gene frequencies are calculated automatically by the method of extracting of the square roots of the frequencies of the homozygotes AA and AA. In the second variant the gene frequencies are automatically calculated according to the formulas: $p = (D + 0.5H)/N$, $q = (R + 0.5H)/N$, where p – frequency of dominant allele, q – frequency of recessive allele, D – number of dominant homozygotes, R – number of recessive homozygotes, H – number of heterozygotes, N – total number of members of the population. Both methods allow us to formulate the main conclusion, that in ideal populations, the ratio of frequencies of genes and genotypes remain constant from generation to generation, and the sum of their frequencies is equal to 1.

2. Modelling of population genetic structure, which is influenced by factors of change in its genetic structure – natural selection, gene flow, genetic drift. Entry of simulation results into a table on web pages http://mybio.education/mod/exp3/en/index.html, http://mybio.education/mod/exp4/en/index.html, http://mybio.education/mod/exp5/en/index.htmlrespectively.

Before usage of web pages for entering the results of the simulation, high school students work with persisted models of alleles of dealing a gene and create a genetic model of the parent population. These materialized models can be checkers, chips, candies, balls of different colours. The educational models of the genetic structure of the population are the findings of the experimental action with the model elements first ratio of genotypes and ratio of frequencies of genes, that is, the ratio of frequencies of genotypes and genes in the parent population.

On each of the web pages there is an instruction for the sequence of actions that must be performed concerning materialized objects, as well as actions to enter the received results in the tables for automatic calculation of genotype frequencies and allele frequencies. The rows that are highlighted in blue in tables for web pages http://mybio.education/mod/exp1/en/index.html, http://mybio.education/mod/exp2/en/index.html, http://mybio.education/mod/exp3/en/index.html or http://mybio.education/mod/exp4/en/index.html, http://mybio.education/mod/exp5/en/index.html are filled manually by students on the basis of counting of the number of the results obtained in the course of the materialized models of alleles and genotypes. The web pages provide automatic plotting of graphs and charts, allowing, first, to reveal the results in graphical form (figures 4, 5). Secondly, it allows to effectively carry out their comparative analysis and to formulate conclusions according to the algorithm of the action plan.

Both diagrams show the genetic structure of populations and according to the semantic content they are identical. They differ in the way of the visibility of the results. The teacher can draw the students' attention to one variant of a diagram with a proposal to compare the genetic, genotypic structure of the population in generations. There is another, more complicated version of the analysis of the constructed diagrams. For this the students choose their own chart to analyze data and formulate conclusions.

Both variants have advantages and disadvantages. In the first variant of the diagram, numeric data of the results of the experiment are included in the corresponding segments of each column. All the data are displayed on the screen, so the student can quite easily compare the numbers.

In the second variant, the segments of each column are located one behind the other, and so that the first, the most narrow segment corresponds to the parent generation and the last, the widest one corresponds to the last child generation. This way of presenting data is liked by students because, not even using numerical data it is visually easy to compare the size (height) of colored bars. Besides, when one aims the cursor at the corresponding field the necessary numerical information appears on the screen.

Analysis of the received data of the model experimentation by the students is carried out on the basis of the analysis of the built:

1) graphics of genetic and genotype structure of the population in generations;
2) one of the diagrams of the genetic structure of the population in generations;
3) graphs and diagrams that overlap.

A variety of graphic options allows to acquaint students with the methods of their statistical processing and presentation.

Testing of the developed web pages and work on the proposed methods during 2015–2018 demonstrated that the proposed options did not allow working with a large number of experimental objects. That is, it was impossible to comply with the condition of the mass scale of the experiment. In addition, the question of the replicativity of the experiment also remained open. The reasons are as follows:

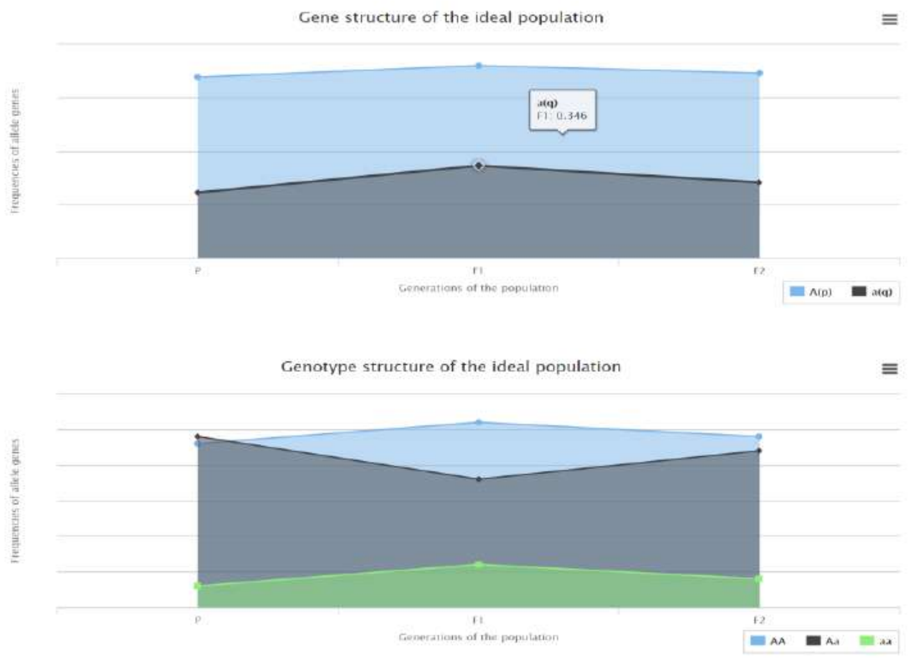


Figure 4: View of graphics on the web page that were built in automatic mode http://mybio.education/mod/exp1/en/index.html.

1. It is physically impossible in the course of the educational process to explore a large number of material model objects – homozygous dominant, homozygous recessive and heterozygous individuals. The work was accompanied by the enormous time spent on manual modelling and counting of randomly formed pairs of alleles. Such a calculation had to be carried out both within one generation, and in several replications. Note that in this variant we are talking about the difficulties with the technical replication of the experiment.
2. The use of material models was limited to elementary material costs for the manufacture of model elements. The maximum number of individuals whose genotype models were used in the experiment was equal to 50. In the case of diallelic inheritance of a trait (as the simplest variant of inheritance), the number of alleles was equal to 100. Let's point to the fact that in the classrooms there were carried out parallel experiments on the study of influence of different factors of the dynamics of the population genetic structure, the work was carried out in small groups, each of which worked with a separate set of elements for modelling. There were 5 such groups. The first group studied the genetic structure of an ideal population in generations. The second group studied the effects of gene drift. The third group studied the essence of the gene flow phenomenon. The fourth group studied the influence of natural selection on the genetic structure of the population. The fifth group studied the role of the mutational process in the dynamics of the genetic structure of the population. In total, at least a set of 500 material elements was needed for modelling.

We place the emphasis on the fact that even with 50 simulated members of the population, we obtained results that allowed to illustrate the essence of genetic transformations in populations in the absence of any factors and in their presence.

In work on the improvement of the experimental methodology, we tried to: 1) get closer in school modelling of genetic-evolutionary processes to the real process taking a course in populations; 2) take into account significant differences and commonality between scientific and educational experiment. Particularly, this was expressed in the fact that it was necessary to:

1. Cover by the experiment the maximally large number of individuals. It has been assumed that the hundreds and thousands of individuals could be the experimental objects.
2. Reduce the amount of routine work for students on the calculation of the resulting genotypes and

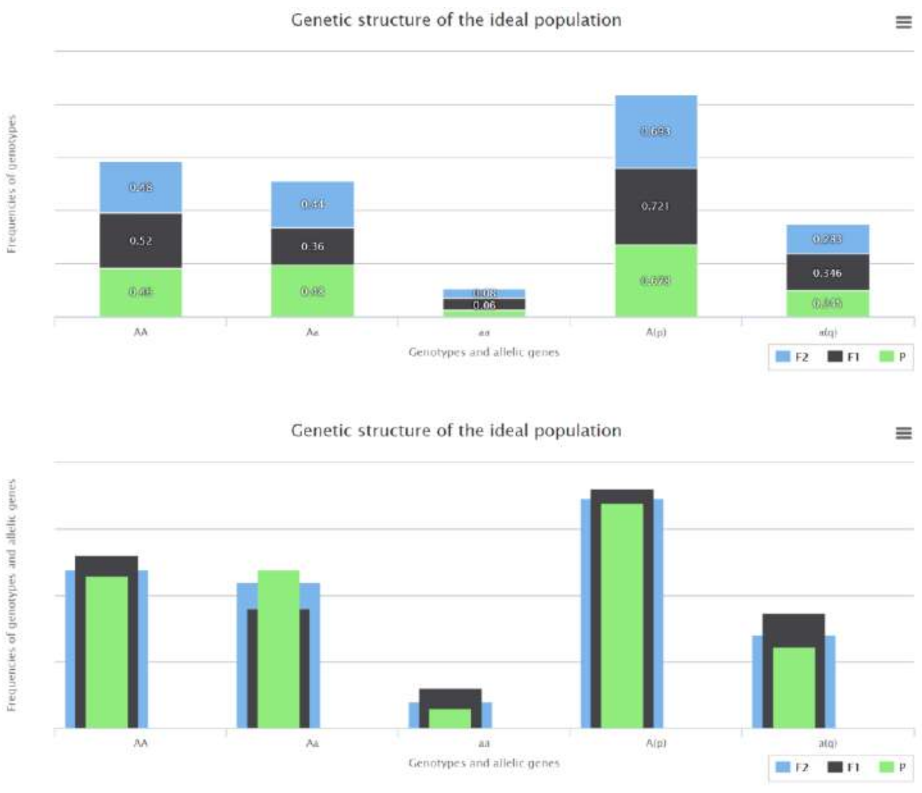


Figure 5: View of diagrams on the web page that were built in automatic mode.

alleles in one generation.

3. Simulate a larger number of replications (replicates) of the experiment, which would increase the veracity of results and their closeness to the mathematical formula of Hardy-Weinberg. We also set the task to provide the possibility for technical and biological replication of an experiment on one topic.

Thus, we set the task to provide the possibility of technical and biological repetition of an experiment on one topic.

Taking into account the abovementioned tasks, we have developed a web page http://mybio.education/mod/exp6/en/index.html (Model experiment 1. Study of the genetic structure of the ideal population (third variant).

Using the tools of this web page, we can conduct an experiment on the modelling of a structure of an ideal population in the absence of such factors as natural selection, gene flow, gene drift, mutations. Note that this is the third variant for conduction of a model experiment on the stated topic. The first two are displayed on the following pages: http://mybio.education/mod/exp1/en/index.html and http://mybio.education/mod/exp2/en/index.html.

What is the difference between the proposed third variant?

First. In two early variants, the number of individuals was limited by the physical ability to manually count the resulting pairs of alleles and the number of material elements for modelling. The studied population in the proposed variant can be very large – several hundreds, thousands, millions of individuals. This contributes to the implementation of the first of the tasks pursued by us – an increase in the number of objects used in the model experiment. And in this case, it can be considered as a step towards the increase in the veracity of the experimental results. And thus, the maximum convergence with the actually occurring genetic and evolutionary transformations in the population. For example, for an experiment, you can take several tens of thousands of individuals and several million (figures 6, 7).

Second. The user (student) can independently enter the initial allele frequencies in the graph for the parental population. In the first two variants, the allele frequencies were calculated automatically after data entering by the manual calculation of the ran-

Model experiment 1. Study of the genetic structure of the ideal population (third option)

1. In column 2 for the parent generation P, we introduce the number of pairs of two-body gene alleles (in other words, the number of individuals).
2. We are determined by the ratio of the dominant (A) and recessive (a) alleles, and we introduce their values in columns 9 and 10 for the parent generation P.
3. Click the "Calculate" button.
4. Click the "Calculate" button opposite the lines F1, F2, F3, F4, F5.
5. Click on the "Show Graphs" button.
6. Based on the analysis of the obtained graphs and diagrams, formulate the conclusions of the plan:
   - Change in the frequency of genotypes in generations;
   - Change in the ratio of gene frequencies in generations;
   - The direction of evolutionary changes in the population.

Table 6. Genetic structure of the ideal population

Generation	Number of individuals	Distribution of genotypes						Gene frequencies		
		AA		Aa		aa		A(p)	a(q)	
1	2	3	4	5	6	7	8	9	10	
P	20000	10910	0.545	6180	0.309	2910	0.145	0.7	0.3	Calculate
F1	20000	10893	0.545	6214	0.311	2893	0.145	0.738	0.380	Calculate
F2	20000	10883	0.544	6234	0.312	2883	0.144	0.738	0.380	Calculate
F3	20000	10890	0.544	6220	0.311	2890	0.144	0.738	0.380	Calculate
F4	20000	10823	0.541	6354	0.318	2823	0.141	0.736	0.376	Calculate
F5	20000	10869	0.543	6262	0.313	2869	0.143	0.737	0.379	Calculate

Show Graphs

Figure 6: Results of a model experiment with a number of 20000 individuals, allele frequencies p (0.7) and q (0.3).

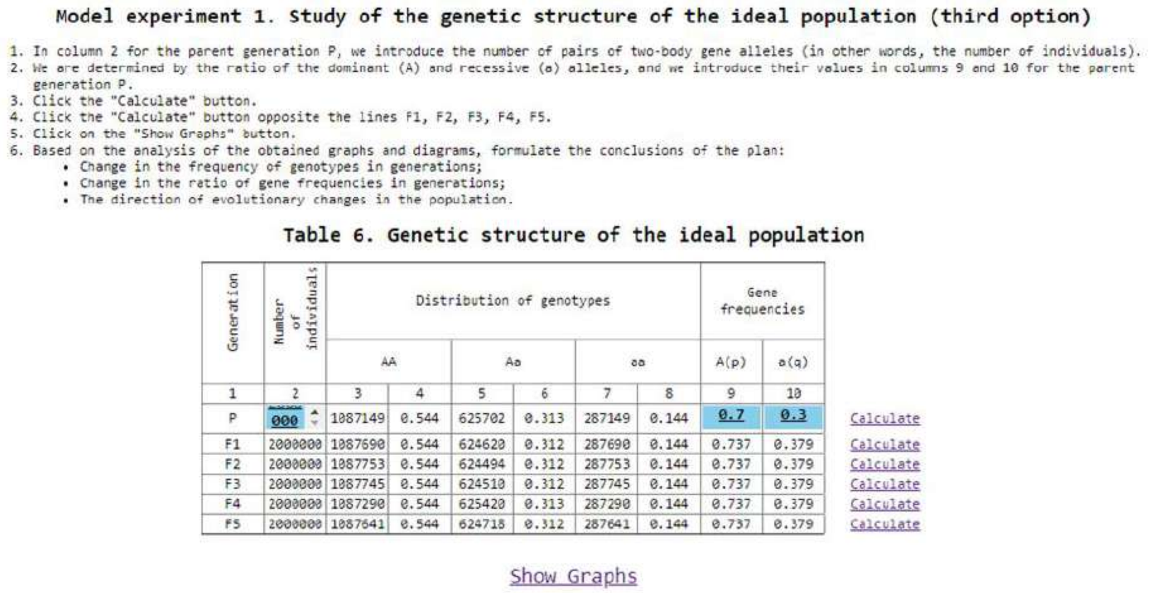
domly obtained genotypes. This function opens up an opportunity to demonstrate the essence of **biological replication of experiments**. This function is especially remarkable in the lesson during the simultaneous work of several groups of students with different populations in number and frequency of alleles occurrence (figures 6, 8).

Third. The number of generations of the population has been increased. In the proposed variant, it is equal to 5. I.e. together with the parental population, the total number of replications of the experiment is equal to 6. In previous variants of the experiment, the number of replications was equal to 3 (one parental generation and two daughter generations). In addition, note that it is technically possible to increase the number of replications by times. This will offer an opportunity, first of all, to quickly get a picture of the genetic structure of the population, without bothering students with mechanical work on mixing and distribution of genotypes, since there is an automatic distribution of genotype frequencies within the limits of the ideal population. Secondly, it contributes to the implementation of one of the tasks pursued by us – an increase in the number of replications of the experiment within the limit of one sample (population). This function opens an opportunity to conduct the **technical replication of experiments**.

The visualized replication results are displayed on the user's screen by clicking the "Show graphs and diagrams" button. Note that in one session the user can only see the results of technical replication, i.e. distribution of alleles and genotypes in generations with initially specified parameters (number of individuals and allele frequencies). The generations of the population will act as technical replications. In order to simulate biological replication, it is necessary to load the page once again without closing the previous one and enter other initial data (the number of individuals, allele frequencies). Within each session, generations of a population in relation to each other will act as technical replications, but in relation to the first population and its generations – biological replications.

3.2 The Results of the Experimental Stage of the Study

In 2019/2020 academic year, the developed web page was tested with the participation of 6 students of the 3rd year of the Institute of Living Systems of Immanuel Kant Baltic Federal University, in specialty "Biology" and 12 students of the 11th form of the Municipal Budgetary General Education Institution General Secondary School "School of the Future" of Guryevsky district of Kaliningrad Region (Russian Federation). The approbation took place within the framework of carrying out by Municipal Budgetary General Education Institution General Secondary School "School of the Future" together with the National Research University Higher School of Economics of the conference "Effective High School" (January 23–25, 2020). Within the framework of the conference, there were organized practical classes for



Model experiment 1. Study of the genetic structure of the ideal population (third option)

1. In column 2 for the parent generation P, we introduce the number of pairs of two-body gene alleles (in other words, the number of individuals).
2. We are determined by the ratio of the dominant (A) and recessive (a) alleles, and we introduce their values in columns 9 and 10 for the parent generation P.
3. Click the "Calculate" button.
4. Click the "Calculate" button opposite the lines F1, F2, F3, F4, F5.
5. Click on the "Show Graphs" button.
6. Based on the analysis of the obtained graphs and diagrams, formulate the conclusions of the plan:
   - Change in the frequency of genotypes in generations;
   - Change in the ratio of gene frequencies in generations;
   - The direction of evolutionary changes in the population.

Table 6. Genetic structure of the ideal population

Generation	Number of individuals	Distribution of genotypes						Gene frequencies		
		AA		Aa		aa		A(p)	a(q)	
1	2	3	4	5	6	7	8	9	10	
P	000	1087149	0.544	625702	0.313	287149	0.144	0.7	0.3	Calculate
F1	2000000	1087690	0.544	624620	0.312	287690	0.144	0.737	0.379	Calculate
F2	2000000	1087753	0.544	624494	0.312	287753	0.144	0.737	0.379	Calculate
F3	2000000	1087745	0.544	624510	0.312	287745	0.144	0.737	0.379	Calculate
F4	2000000	1087290	0.544	625420	0.313	287290	0.144	0.737	0.379	Calculate
F5	2000000	1087641	0.544	624718	0.312	287641	0.144	0.737	0.379	Calculate

Show Graphs

Figure 7: Results of a model experiment with a number of 2000000 individuals, allele frequencies *p* (0.7) and *q* (0.3).

students of 11th grade on the topic “Modelling of the genetic evolutionary processes in the population”. One of the proposed experiments for carrying out was a model experiment “Study of the genetic structure of an ideal population” according to the methodology updated by us without using material objects.

In approbation, the participants were divided into 2 groups (3 students and 6 students). One group was asked to start with an experiment at http://mybio.education/mod/exp1/en/index.html, and then at http://mybio.education/mod/exp6/en/index.html. Another group was asked to click a link to the web page http://mybio.education/mod/exp6/en/index.html (Model experiment 1. Study of the genetic structure of the ideal population (third variant) and simulate the genetic structure of a population of any number more than a thousand with an arbitrarily given combination of allele frequencies. It was proposed three times to the participants to carry out model experiment in the third variant with different initial data (number of individuals of the population, allele frequencies). Each of the participants of the approbation both in the first and second groups in carrying out of the third variant of the experiment worked separately. The participants were asked to use the “Show graphs and diagrams” function, and also to formulate conclusions at the end of the experiment.

The goals pursued by us were as follows:

1. To find out the availability of understanding by users of the tasks and results of experiments.
2. To find out the main difficulties faced by users when working with a web page http://mybio.education/mod/exp6/en/index.html.

During the oral survey of the participants in the experiment, it was found:

1. Participants of the first group, when conducting an experiment with material objects at the beginning of work, hardly understood the essence of the performed similar actions. Only after data entering into the table, calculation of the frequencies of alleles and genotypes, the understanding of the meaning of the uniformity of actions came.
2. Participants of the first group complained about the routine of the performed actions, increased fatigue during their performance. Participants sought to complete the experiment more quickly, which increased the error rate in calculation of the absolute number of genotypes. The latter was displayed at the frequency of genotypes calculated by the program. Thus, the obtained results in several cases were erroneous, the experimental actions had to be performed over again.
3. Participants of the first group, after passage to the second experiment, which, in fact, duplicated the first variant, but did not require manual counting, expressed great approval of the possibility to operate only with numbers.
4. Participants of the second group completed the assigned task more quickly. However, in both groups, there arose questions about the purpose of three-time replicate of the experiment (with dif-

Model experiment 1. Study of the genetic structure of the ideal population (third option)

1. In column 2 for the parent generation P, we introduce the number of pairs of two-body gene alleles (in other words, the number of individuals).
2. We are determined by the ratio of the dominant (A) and recessive (a) alleles, and we introduce their values in columns 9 and 10 for the parent generation P.
3. Click the "Calculate" button.
4. Click the "Calculate" button opposite the lines F1, F2, F3, F4, F5.
5. Click on the "Show Graphs" button.
6. Based on the analysis of the obtained graphs and diagrams, formulate the conclusions of the plan:
   - Change in the frequency of genotypes in generations;
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Table 6. Genetic structure of the ideal population

Generation	Number of individuals	Distribution of genotypes						Gene frequencies		
		AA		Aa		aa		A(p)	a(q)	
1	2	3	4	5	6	7	8	9	10	
P	20000	2295	0.115	3410	0.171	14295	0.715	0.2	0.8	Calculate
F1	20000	2261	0.113	3478	0.174	14261	0.713	0.336	0.844	Calculate
F2	20000	2310	0.116	3380	0.169	14310	0.716	0.340	0.846	Calculate
F3	20000	2274	0.114	3452	0.173	14274	0.714	0.337	0.845	Calculate
F4	20000	2221	0.111	3558	0.178	14221	0.711	0.333	0.843	Calculate
F5	20000	2285	0.114	3430	0.172	14285	0.714	0.338	0.845	Calculate

Show Graphs

Figure 8: Results of a model experiment with a number of 200000 individuals, allele frequencies p (0.2) and q (0.8).

ferent number of population and allele frequencies). Note that practically no questions arose in both groups regarding the advisability of repeating the experiment in generations of the same population. It follows that the essence and necessity of technical replication is recognized and accepted by the participants.

With biological replication, the situation is different. Its objectives were not clear to the participants, most likely due to a lack of methodological awareness of this type of replication.

Before the performance of the experiment, we deliberately did not focus the participants' attention on the goals of repeated replicate of experimental actions. This was done in order to find out whether the participants understood the conditions for the veracity of the results of the biological experiment. Since among the examinees there were both students of a biological specialty and students of graduating profile chemical and biological classes. We assumed that the participants already possess the necessary methodological tools for planning, conduction of biological experiments and interpretation of the results. The results of approbation showed that teaching the methodology of a biological experiment should be started with distinguishing between technical and biological replication of experimental effects. We can only assume that a lack of understanding of the differences between them (for purposes, methodology) could initiate the spread of the problem of pseudoreplication in biological research in principle. We believe that in order to confirm this assumption, it is necessary to conduct additional studies aimed at a retrospective analysis of biological scientific literature, primarily of scientific papers, conference materials containing a description of the methods and results of experiments. The question is, is it worth doing? Or to accept the fact that even if we consider the problem of pseudoreplication as far-fetched, then the issue of distinguishing between technical and biological replications and teaching this in the secondary school and in higher educational establishment definitely deserves further study.

4 CONCLUSIONS

As a result of work on the topic of overcoming methodological difficulties in conducting a model experiment on population genetics, we came to the following conclusions:

1. Model experiment on the study of genetic-evolutionary processes in populations by means of computer modelling is ideal for demonstration of the essence of technical and biological replication.
2. The use of technical and biological replication in a model experiment makes it possible to take into account the requirement of repetition and mass scale of the experimental impact. This is neces-

sary to obtain reliable results.

3. In the educational model experiment, it is impossible to take into account all the requirements for a scientific biological experiment, therefore, it is necessary to rely only on its essential features.

5 OUTLOOK

Further work on studying the possibilities of a model experiment in training of the students of 11 grade and students-biologists in true replication, as well as the essence of technical and biological replication, we can see in the following. It is necessary to develop and approbate web pages to model the structure of a very large population under the influence on its numerous generations of such factors as natural selection, gene flow, gene drift, mutations.

The modelling of the genetic structure should be fully automated. The initial platforms for improvement of methodology will be the existing web pages http://mybio.education/mod/exp3/en/index.html (Model experiment 2. Study of the genetic structure of the population under the influence of natural selection), http://mybio.education/mod/exp4/en/index.html (Model experiment 3. Modelling the effect of gene flow on the genetic structure of the population), http://mybio.education/mod/exp5/en/index.html (Model experiment 4. Modelling the effect of random processes on the genetic structure of the population, modelling the drift of genes*), providing one of the stages of work with material objects.

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The Evolution of the Information and Educational Environment in the Context of the Theory of Generational Development

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Keywords: Learning Environment, E-Learning, Blended Learning, Baby Boomers, Generations X, Millennials, Generation Y, Generation Z.

Abstract: The article is devoted to reviewing system-organizing and personalized approaches to the modern learning environment. It is explored following modern society's requirements and technology. We suggested 6 stages in the development of the learning environment, stages of e-learning development, visualized the interdisciplinary approach to EdTech and comparative characteristics of traditional and e-learning. E-learning is understood as an umbrella term that covers web-based instruction, online learning, networked learning, computer-assisted learning and computer-mediated learning. We consider a model of the modern learning environment taking into account the characteristics of its subjects belonging to different generations. Generation theory is reviewed providing recommendations for the best possible educational content for Baby Boomers, Generations X, Millennials or Generation Y and Generation Z suitable to their adaptive style and values.

1 INTRODUCTION

The educational process is changing due to the evolution of society all the time. Now we are witnesses of higher education transformation and adaption of student's workplace for various forms of using traditional and ICT learning tools. The advances of digital multitools provide wide access to various kinds of information sources, widening the walls of the educational institution.

According to the 2030 Agenda for Sustainable Development announced in 2015 Sustainable Development Goal 4, known as Education 2030, is a single global goal for quality education, which aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. Technology is a fundamental driver of that vision to create equitable, dynamic, accountable and sustainable learner-centred digital learning ecosystems that are relevant for the XXI. Rapid advances in technology are revolutionizing how teaching and learning are conceptualized, designed, and implemented in higher education. These developments play a key role in delivering quality education for all (Ping and Libing, 2017).

In today's world of dynamic society development, scientific and technological progress, approaches to the learning environment are changing. This is due to many factors, including the change of generations that respond differently to information appeals and the technology of their delivery.

In 1991 Strauss and Howe (Strauss and Howe, 1991) presented the theory of generations. According to it, people of the same age group are united by common features formed by their live conditions. As a result, Strauss and Howe (Strauss and Howe, 1991) had 6 generations in the XX and XXI centuries. The last four generations of the XX century, and those which make up most of the current learners' population, can be seen (in bold) in table 1. Some slight variation exists in the span of years used for each group (Jones et al., 2007).

Focusing on generation theory can help to develop more robust theories of flexibility in the contemporary learning environment, as well as to provide the best possible educational content for Baby Boomers, Generations X, Millennials or Generation Y and Gen-

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Table 1: Demographics by generation.

Cohort	Year of Birth
G.I Generation	1900 to 1921/1924
The Silent Generation	1922/1925 to 1943/1946
The Baby Boomers	1944/1947 to 1960/1963
Generation-X	1961/1964 to 1978/1980
Millennial / Generation-Y	1980/1982 to 2000/present day
New Silent Generation / Generation Z	2000/2003 to 2020 /?

eration Z suitable to their adaptive style and values.

The majority of today's students fall into the generational group, Millennials. However, modern educational environment participants are mixed of 4 generations. To provide the best possible educational environment for Baby Boomers, generations X, Y and Z we should be implementing appropriate educational technology.

EdTech or EduTech, being a shortened form for Educational technology, is a wide field. Therefore, one can find many definitions, some of which are conflicting. We consider EdTech as the practice of introducing technologies and non-standard solutions to education for better learning. In 2017, investments in the EdTech market in the world grew to a record $ 9.5 billion. And it is forecasted that by 2020 this mark will cross $ 252 billion (Himyak, 2018).

What started as an experiment in education delivery is now being transformed by a new breed of technology entrepreneurs. Moreover, EdTech is about applying digital technology to deliver a new form of learning architecture. An architecture that harnesses the social reach of the internet delivers personalized learning and training that can automatically adjust to an individual's learning competence and that uses big data analysis to understand the most effective ways for learners to progress. In changing the traditional architecture of education, EdTech has the power to create efficiencies, cut costs and enable new levels of standardization and democratized access. It is set to transform the future of how education is resourced, taught, consumed and, ultimately, the results that it can then yield – both for the individual and for society as a whole as we continue to build the knowledge economy (Vedrenne-Cloquet, 2018).

That's why today teachers are allowed to create an interactive learning environment. Attention should be paid to modelling systems in education following ICT evolution from a learning tool to educational technology. Such development can be easily explained within the triangle Student – Teacher – Learning Environment.

The teachers and students can be the same or different generations. From the point of view of modern education and its promotion through EdTech, the greatest interest is made of four numerical and active generations: Baby Boomers (BB), Generation-X (Gen-X), Millennials / Generation-Y (Gen-Y) and Generation-Z (Gen-Z) who are the main consumers today. Understanding the generational differences in education, their behaviour features and basic values, educators change approaches to educational technology.

2 DEVELOPMENT OF LEARNING ENVIRONMENT

The informational and educational environment is a systemically organized set of data transmission means, information resources, interaction protocols, hardware-software and organizational-methodical support, focused on meeting the needs of users for information services and educational resources.

Developing a total learning environment for students in a particular course or program is probably the most creative part of teaching. While there is a tendency to focus on either physical institutional learning environments (such as classrooms, lecture theatres and labs), or on the technologies used to create online personal learning environments (PLEs), learning environments are broader than just these physical components. It also includes:

- the characteristics of the learners;
- the goals for teaching and learning;
- the activities that will best support learning;
- the assessment strategies that will best measure and drive learning;
- the culture that infuses the learning environment.

Individual learning styles are influenced by generational differences in a learning environment. There is no one-size-fits-all solution to accommodate the learning preferences of all generations. Thus, some approaches work well for learners from one generation but aren't well received by those from other generations. The key is to include a diversity of methods, modalities, and techniques to address a diversity of preferences (see table 2) (Levonius, 2015).

As we can see modern learning environment is more generationally diverse than ever before, and each generation has its unique perspectives and preferences regarding learning. To accommodate all of those preferences can be possible by employing sound instructional methodologies, a variety of modalities, and solid facilitation techniques thus overcoming fundamental generational differences and providing learning experiences that engage and benefit everyone (Levonius, 2015).

The learning environment is used to be concerned with information technology, as the technology for people to work with information. According to this approach, there are 6 stages of learning environment development.

It can be noticed the correspondence of 6 stages of information technology development to a certain generation of its users (table 3).

Thus, pedagogical technology reflects the tactics of the implementation of educational technologies and is based on the knowledge of the regularities of the functioning of the system 'Teacher – Environment – Student' in certain study conditions (individual, group, collective, mass, etc.), it shares the common features and regularities of the educational process independently from a particular educational subject.

D. Charrisony and S. Nipper first used the term 'generation' to refer to three stages of e-learning development, "historically related to the development of production, transport and communication technologies" (Nipper, 1989). Table 4 presents a brief description of three generations of e-learning.

According to table 4, each direction of pedagogy of distance education is characterized by certain features of the social, cognitive component in the process of distance learning.

The first generation – 'cognitive behaviourism' – emphasizes the need to use the model of distance learning, the goals of which are clearly defined, formulated and exist separately from the students and the content of learning. The training material should be constructed in such a way as to maximize the effectiveness of the mental activity. This generation is characterized by the absence of a 'social' in the process of learning. The study is considered an individual process. A similar emphasis on individualized learning improves students' autonomy. Preferably such technologies as radio, television, postal correspondence [periods] are used. The presence of a teacher in the learning process is extremely limited. The role of the teacher is mainly in the preparation of printed material. Later, students could see and hear the teacher through audio, video, multimedia technology.

Instead, 'constructivism' as the next generation comes, the main principles of which are the following features:

- new knowledge is built based on prior knowledge;
- distance learning is considered as an active rather than a passive process;
- language and other social tools play a role in building knowledge;
- the purpose of cognition and evaluation is a means of developing students' abilities to self-assess knowledge;
- the student is the core of the learning environment;
- the knowledge acquired in the process of distance learning must be subjected to discussion by the community, verification and real use (Nipper, 1989).

The teacher in this case is a mentor, assistant and partner, and the content of the teaching material becomes secondary to the learning process. The teacher and his experience are still the main sources of knowledge.

The next generation of pedagogy of distance education – 'connectivism' – involves unlimited access to network technologies. According to this approach, the role of the student is not to remember all the information, but to be able to find information and apply knowledge where necessary. For training with the use of distance learning technologies, students need to have a high level of information and communication competence, therefore, the primary task is to prepare students for learning with the use of special learning technologies. Teachers and students can collaborate in content development, offer ideas for improving teaching technology. The entire distance learning process is carried out based on cooperation. However, this direction is characterized by the lack of pedagogical control, the structuring of educational content.

Anderson and Dron (Anderson and Dron, 2011) believe that each of the generations has its advantages and disadvantages. The future generation of distance learning, according to scientists, will be more subject-oriented, characterized by an increase in student activity in the learning process, learning virtualization.

Generally, e-learning has been used to describe learning that is supported by technologies through various types of delivery modes.

Table 2: Generational differences in the classroom (Levonius, 2015).

Generation	**Learning characteristics**	**What to provide for the group**
The Silent Generation	They prefer to work in the background, synthesize the ideas of others, and build consensus rather than speaking up, advancing their agendas, or engaging in debates. They respect authority, do what is asked of them, and remain on task until the job is done.	instructor-directed lectures, structure and predict-ability (no surprises), independent skill practice time
Baby Boomers	They are internally focused yet extrinsically motivated. With a strong self-efficacy, they expect themselves to easily achieve mastery. They prefer democratically run classrooms and enjoy working collectively, provided their group has an achievable mission and a spirit of cooperation. Although they enjoy interacting with others, they prefer to experiment with new skills independently and can be very sensitive to criticism.	inclusive decision-making, group interactions and discussions, chances to try new skills independently
Generation X	Gen Xers are intrinsic learners who view learning as an independent, self-directed activity. They are the only generation in which fewer of them went to college than their parents. In the classroom, they are self-motivated, provided they see the learning as relevant and place greater value on work-life balance and fun than did their workaholic parents. They can be somewhat impulsive and impatient in group learning environments and prefer to be given lots of discretion, yet they often crave lots of individual attention and feedback.	fun activities, relevance, and understanding of WIIFM (what's in it for me?), discretion to complete tasks their way
Millennials	They prefer participatory, activity-based group work, although they are accustomed to being evaluated and graded on an individual level. They will strive to earn high marks for themselves and their teams and may even bend the rules when necessary to do so. They are the first generation to have used technology their entire lives, so they expect to use it everywhere they go, including the classroom	lots of activity-based group work, individualized feedback and mentoring, technology-enabled learning and use of their own devices during class

Since 2002, e-learning has become an umbrella term that covers web-based instruction, online learning, networked learning, computer-assisted learning and computer-mediated learning (Littlejohn and Pegler, 2007). All of these terms refer to the use of information and communications technologies in learning. The relationship between e-learning, Information Technology (IT) and Information and Communication Technologies (ICT) is identified in the eclipse diagram (figure 1 shows that e-learning is based on Information Communications Technologies, which is derived from Information Technologies, to offer to learn).

E-learning often refers to technology or designs used in distance teaching, but it also is used to describe any sort of technology use in education. As of 2019, e-learning has been replaced by the word 'digital learning' or sometimes EdTech (edutech-wiki.unige.ch, 2021). We prefer to continue using 'educational technology', although the term 'digital learning' is more open to the idea that technology has become a general omnipresent tool, i.e. encompasses any sort of technology use in education.

To understand how corporate web-based learning can be optimized to address the learning style preferences of today's generationally diverse workforce, it is important to understand the existing literature, which falls into three categories. Figure 2 depicts the conceptual framework (Kriegel, 2013).

There is a logical progression to the three streams. First, it is important to understand what the empirical research reveals about generational differences in learning preferences as it pertains to learning styles and also learning activities. Second, what the current and emerging practices in web-based learning are. Third, in what manner the resultant data can be used to inform instructional design best practices. That is, specific recommendations can be made to optimize the instructional design for web-based learning delivered to the 21st century, generationally diverse

Table 3: Correspondence of 6 stages of information technology development to a generation of users.

Generation	Stage of information technology development
G.I Generation	The 1st stage (up to the second half of the XIX century) was 'Hand' information technology, its tools were pen, inkpot, book. Communications were carried out handily by sending information with mailing lists, packages, dispatches. The main aim of information technology was to provide information in the necessary form.
The Silent Generation	The 2nd stage (since the end of the XIX century) was 'Mechanical' technology; its tools for delivering information were typewriters, telephone, and voice recorder. The main aim of information technology was to provide information in a necessary form in the most convenient way.
Baby Boomers	The 3rd stage (40–60s of XX century) was 'Electric' technology; its tools were developed to electric typewriters, Xeroxes, portable Dictaphones. The emphasis of information technology started to move from the form of information presentation to making its content.
Generation X	The 4th stage (since the beginning of the 1970s) was 'Electronic' technology, its tools were ECM and created on their basis automated control systems (ACS) and information retrieval systems, equipped with a wide range of basic and specialized software complexes.
Millennials / Generation y	The 5th stage (from the middle of the 1980s) was 'Computer' (New) technology, the main tool of which is a personal computer with a wide range of standard software products for various purposes. At this stage, there was the process of personalization of the ACS, which manifests itself in the creation of decision support systems by certain specialists.
New Silent Generation / Generation Z	The 6th stage (now developing) is 'Network' technology (sometimes it is considered as a part of computer technology). Global and local computer networks are beginning to be widely used in various industries.

workforce (Kriegel, 2013).

Educational technology can be considered as a design science and as such, it has developed some specific research methodology like 'Design-based research'. However, since it addresses also all fundamental issues of learning, teaching and social organization, educational technology makes use of the full range of modern social science and life sciences methodology.

3 THE REFERENCES FOR LEARNING TECHNOLOGIES AND LEARNING ACTIVITIES BY DIFFERENT GENERATIONS

It is known that within the ICPS during the preparation and implementation of training each student has the opportunity to choose the goals, content, method, place and time of training, and in educational organizations – the opportunity to go in different ways in the provision of educational services that meet the requirements of the labour market and social needs. Table 5 shows the comparative characteristics of traditional and e-learning (Spivakovsky et al., 2019).

Kriegel (Kriegel, 2013) found little variance in learning activity preferences across the generational cohorts. To a surprising degree, each generation liked and disliked the same learning activities presented in the survey. Table 6 presents a summary of the top five, most frequently selected learning activities and the bottom five, least selected learning activities for all participants, organized by generation.

The most frequently selected favourite learning activities were selected with the same frequency regardless of generation. These included reviewing information in graphic format, using search engines for online research, using various online simulations, and reviewing FAQs. Likewise, the least favourite learning activities were also selected with the same frequency, regardless of generation. These were using Twitter communities, desktop sharing, online discussion boards, completing surveys, and online brainstorming canters (Kriegel, 2013).

It is expected that the type of technologies for learning and the way they will be used will change the future of education. Nowadays, the common online tool used in blended learning is called Web 1.0. In Web 1.0, information is delivered to users while in Web 2.0 information is created and edited by users.

Table 4: Generations (stages) of e-learning development.

Learning theory	Generation	Student's activities	Learning mode	Training content	Teacher's role
Cognitive behaviourism	Television, radio, print, face-to-face communications	Reading and reviewing materials	Individual training	Developed 'from scratch'	Creator of the content
Constructivism	Audio, video and web conferencing	Discussion, development, design	Learning in groups	Constructed and developed by a teacher	Head of the discussion
Connectivism	Web 2.0: social networking, an association of users	Research, connection, creation, evaluation	Network learning	Autonomic	A friend that critically evaluates

Web 1.0 is a read-only environment, while Web 2.0 is a read and write environment which facilitates social activities. Blogs, Wikis, Twitter, YouTube, Facebook, and Flicker are examples of the most common Web 2.0 tools. Globally, the number of users of Web 2.0 has increased dramatically (Alebaikan and Troudi, 1).

At the same time, e-learning 2.0 promotes collaboration in knowledge construction. The rapid innovations in e-learning urge for research about the impact of these innovations on blended learning. Recently, research has started to explore the effectiveness of using Web 2.0 in blended learning. With the continuous development of the use of web-based applications and 3D virtual worlds like Second Life, which can be called e-learning 3.0 (figure 3), there are even more opportunities to create a better engagement blend. The future development of technology will change the delivery modes used, the costeffectiveness and the acceptance and recognition of the new educational environment (Alebaikan and Troudi, 1).

Web 1.0 is a linear model 'site to user', one-dimensional interaction. The owner of a site is the source of information; the readers are its users. There is no feedback between the site and the users as if you can write a letter to the editor or call (like the readers of a newspaper).

Web 2.0 is a social web of two-dimensional interaction. The owner of a site manages the information provided by users following their own rules. Users themselves make publications, write comments, and communicate with each other (social networks). Feedback between the site and users is also absent because users do not formulate rules. Unlike Web 1.0 the owners do not have to fill the site with information as the users do it.

Web 3.0 is a social space, three-dimensional self-organization. The higher level of the Web is a condition where the users of a site are its owners and themselves fill in their information according to their own rules. To manage this information resource they knowingly and voluntarily choose the authorities and, if necessary, update them promptly. The defining features of Web 3.0 are self-financing, self-organization and self-control. Additional features of the third Web are mobility (can be used with Smartphone), scalability (easy expansion) and gamification (elements of gaming competition). Social 3D networks, formed on the model Web 3.0, acquire features of the collective mind, so they are also called social neural networks, or ecological networks. As users can communicate with each other, they have an illusion that these conversations have an impact on the website.

Table 7 defines each learning activity in Kriegel (Kriegel, 2013) study as Web 1.0, Web 2.0, or Web 3.0 technology. Some learning activities can be classified into all three categories. For example, practising real-world interactions in online simulations can be a Web 1.0 technology if the program is fairly simple and the individual is interacting with a computer. If the simulation involves multiple users, an element of social collaboration may define the simulation as a Web 2.0 technology. If the simulation is highly advanced and creates a virtual reality, this is an immersive technology and would be considered Web 3.0. As such, some learning activities fall into more than one category.

The most popular Web 2.0 (or collaborative) learning activity was "interacting with peers in a social media forum" and appeared 14th on the list of 22 among all generations. No social media learning activities appeared in any generation's top 10 list. Therefore, all generational groups expressed the same disinterest in this type of learning. This may be since the group is not currently engaged in social media learning in the workplace, or if they are, perhaps the

IT	Information Technology	The computer infrastructure, hardware and software used to process data and deliver information.
ICT	Information and communication technologies	The combination of computing and communication technologies (including computer networks and telephone systems) that connect and enable some of today's most exciting systems, e.g. the Internet.
E-learning	Electronic learning	E-learning is learning supported or enhanced through the application of information and communications technology.
ILT*	Information and learning technologies*	This was used in further education colleges, to refer to the use of information and communication technologies to support the core business of colleges: the delivery and management of learning.

* The current term is e-learning and technology.

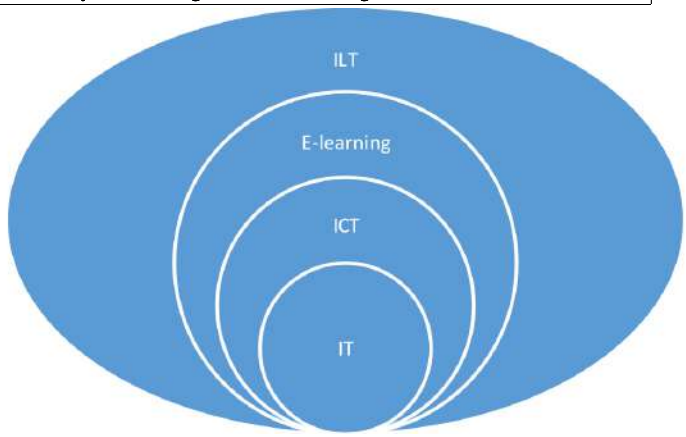

Figure 1: The eclipse diagram and the definitions used in the (dera.ioe.ac.uk, 2004, p. 8).

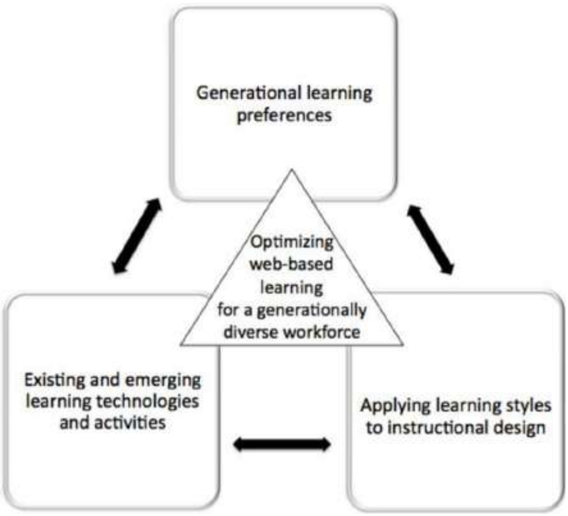

Figure 2: Conceptual framework (Kriegel, 2013).

experience has been poor (Kriegel, 2013).

Besides, the learning activity preferences among generations were also strikingly similar. This particular group was not fond of Web 2.0 activities, such as collaboration and social media in learning. Nor were they interested in using mobile applications or Twitter-like environments to learn. Also, the stereotype of the technologically advanced Millennial generation was not supported in this research. Millennials selected computer simulations less often than

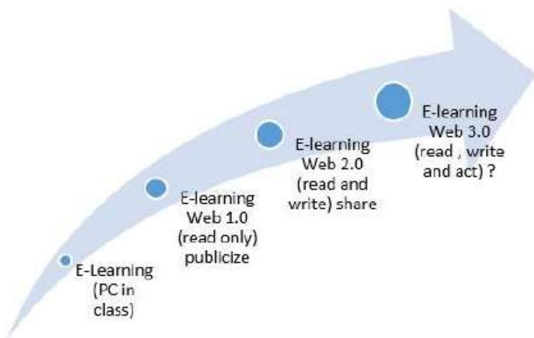

Figure 3: The development of e-learning.

Generation X and Baby Boomers. They also selected designing and drawing more than any other generation. However, these differences were minor. Overall, the three generations enjoy the same learning activities and dislike the same learning activities with little variation. This homogeneity could be because all employees work in the same corporate environment. Therefore, the results, while relevant and useful for the participating company, cannot be generalized to the generational cohorts across all industries and professions. Replicating this study at other organizations and in different corporate settings will be important to understand if generational differences exist in other contexts (Kriegel, 2013).

The research study showed insignificant differ-

Table 5: Comparative characteristics of traditional and e-learning.

Traditional learning	E-learning
Training begins and ends on established dates	The student decides when to begin and complete the study program
The student faces a restriction on the freedom of access to the learning and teaching process	The student has greater access to programming
The student must attend classes at school or in the workplace	The student decides for himself where to study
The objectives and content of the programs are determined by the institution	The student, after consulting with the tutors (teacher-consultant), determines the goals and content of training per his needs and interests
The sequence of training is determined by the program or teacher-consultant (tutor)	The student, together with the tutors develops a work plan and schedule of classes
The speed of learning is dictated by the program, teacher and group of studies	The student, together with the tutor, agrees at his own pace
The teacher provides support mainly through lectures	The tutors and the learner agree on a form of support that can be provided in the form of fulltime study or remotely
The student learns by attending lectures and seminars or studying the scientific and methodological literature	Training is carried out with the help of educational materials, which necessarily include: goals, the actual content, methods of self-assessment and other information for independent work

ences in learning style preferences of the different generations. Besides, there were insignificant differences in learning activity preferences. The results also showed learning styles corresponded closely with learning activity preferences. Surprisingly, there was a lack of interest in learning with Web 2.0 technologies, such as social media forums or Twitter-like environments. This was particularly unexpected as it pertains to Millennials, who are typically known as the techno-generation (Kriegel, 2013).

4 OPTIMIZATION OF WEB-BASED LEARNING TO ADDRESS THE LEARNING STYLE PREFERENCES OF FOUR GENERATIONS

Developing a learning environment also means taking into consideration the differences between generations and find ways to turn generational differences into opportunities. The main goal is to learn, recognize, and understand the differences, then to find ways to recruiting, retaining the students of different generations and supervise the teaching staff generations to make a more productive learning environment.

Thus, we research the ratio of four generations to Kherson State University teaching staff (figure 4). It should be mentioned that Kherson State University is a classical university that is a middle ranged (62th) in Ukraine University rating Top 200. Thus, we consider it can be representative of a common ratio of teaching staff generations with some slight variation exists in the span of percentage used for each group.

According to the results, the main part of the teaching staff is Gen-X (48%), compared with 28% of Baby Boomers, 21% Millennials/Gen-Y and 3% of the Silent Generation. So, the main part of the teaching staff is made of Gen-X, who were born between 1965 and 1980. They are described as flexible, adaptive, techno literate, information savvy, independent, entrepreneurial, self-confident and in perfect sync with the new just-in-time workplace. They also depend on themselves for security and success. Generation X, as employees, are looking for employers that offer:

- flexible schedule;
- performance-based compensation;
- flexible location;
- marketable skills;
- access to decision-makers;
- credit for results achieved;
- a clear area or responsibilities;
- a chance for creative expression.

Modern students are Gen-Z and late Millennials who can be thought to be the main users of digital technology as well as social media. However, according to a new analysis of a Pew Research Center survey of U.S. adults conducted in early 2019 (figure 5) more than nine in ten Millennials (93% of those who turn ages 23 to 38 this year) own smartphones, compared with 90% of Gen Xers (those ages 39 to 54 this year),

Table 6: Summary of the most and the least selected learning activity preferences for all generations.

Learning activity	**Baby Boomers**		**Gen-X**		**Millenials**		**All generations**	
	%	*n*	*%*	*n*	*%*	*n*	*%*	*n*
Most selected								
Reviewing information in graphic format (tables, charts, graphs)	52.4	11	54.2	65	68.8	57	58.1	133
Using search engines for online research	47.6	10	45.8	55	44.3	39	45.2	104
Interacting with computer simulations	61.9	13	49.2	59	34.1	30	44.3	102
Practising real-world interactions in online simulations			45.0	54	37.5	33	40.6	93
Reviewing quick reference guides such as FAQs	42.9	9	30.8	37			32.6	75
Reading text (theories, concepts, non-fiction)	47.6	10			36.4	32		
Least selected								
Engaging in live short (one-hour) webinars					11.4	10		
Using mobile apps to engage in learning via smartphone devices	4.8	1						
Playing multiplayer online games within virtual worlds	4.8	1						
Participating in multiuser online brainstorming centres	4.8	1	8.3	10			9.1	21
Completing questionnaires and/or surveys			10.0	12	6.8	6	9.1	21
Participating in online discussion boards			8.3	10	8.0	7	8.3	19
Observing people online (desktop-sharing)	4.8	1	8.3	10	5.7	5	7.0	16
Sharing snippets of info online in Twitter-like communities	0.0	0	1.7	2	3.4	3	2.2	5

68% of Baby Boomers (ages 55 to 73) and 40% of the Silent Generation (74 to 91) (Vogels, 2019).

Similarly, the vast majority of Millennials (86%) say they use social media, compared with smaller shares among older generations. While the share of Millennials who say they use social media has remained largely unchanged since 2012, the shares of Gen Xers, Boomers and Silents who use social media all have increased by at least 10% points during this period. Unlike smartphones and social media, tablet ownership is now comparable across most generations. Today, 55% of Gen Xers, 53% of Millennials and 52% of Boomers say they own tablets. A smaller share of Silents (33%) reports owning tablets (Vogels, 2019).

According to Cox (Cox, 2019), social media was once associated with only the younger generations, but now, more than 80% of four generations use social media at least once per day for various reasons such as:

- staying in touch with friends and family;
- finding a sense of community;
- searching for solutions to problems or information;
- looking for ideas or inspiration;
- entertainment;
- promoting professional endeavours;
- expanding professional network (Cox, 2019).

As can be noticed all four generations can use social media for education either searching for solutions to problems and information or promoting professional endeavours. That's why understanding the generations' behaviour as the users of learning content allows providing the adequate attraction of learning content for each age group of learners.

If we consider Baby Boomers as a group of learners, they are characterized by the following deep values. This is a generation of experts who need proves and detailed examples. They like to be informed. The purpose of the learning process for them is the knowledge itself and skills. Accordingly, the learning content should be informative in terms of the knowledge, its practical usage, and form in learners' minds a high status as the knowledge itself, its practice, and increase a person's self-esteem from managing the skills. One of the most effective attractive messages for them is the problem and its solution by knowledge and skills. This generation reads the press, watches TV, listens to the radio, so educational content in the media such as newspapers, magazines, television, ra-

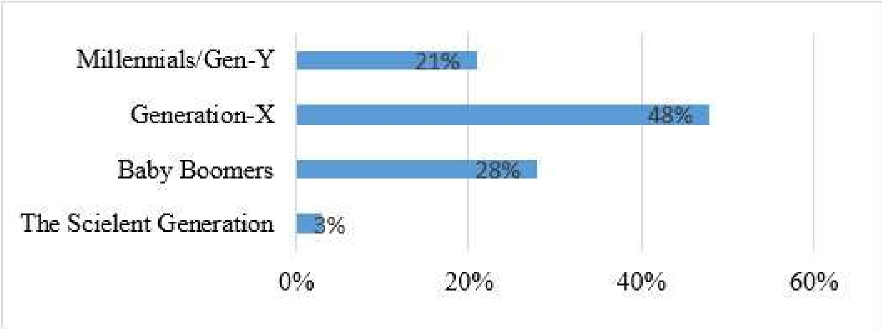

Figure 4: The ratio of four generations to Kherson State University teaching staff.

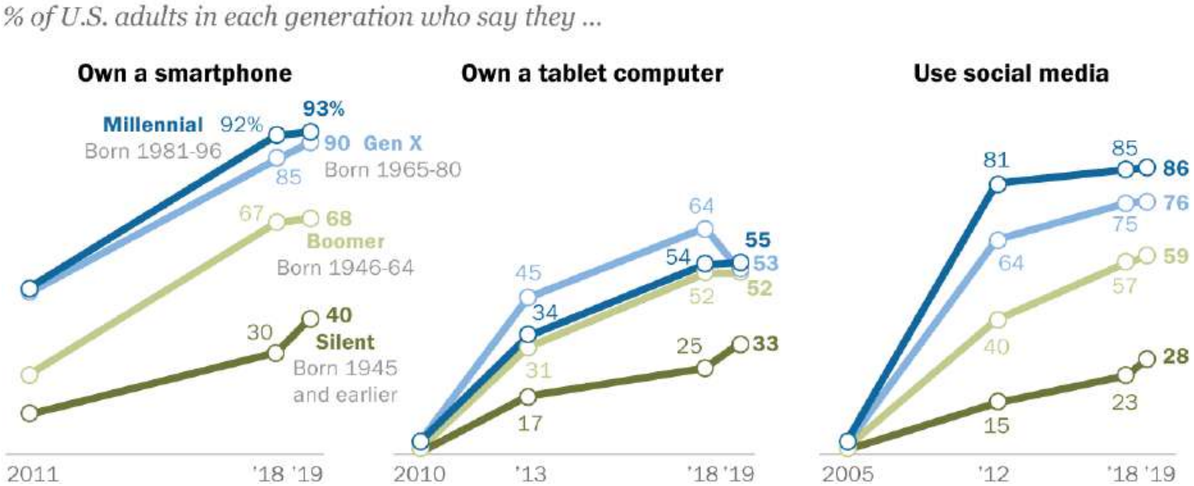

Figure 5: Millennials lead on some technology adoption measures, but Boomers and Gen Xers are also heavy adopters (Vogels, 2019).

dio is the most effective. The Baby Boomer generation is less likely to study online, due to the small proportion of Internet users. Thus, according to the InMind agency, in Ukraine, 10.7% of Internet users are in the age category of 50-59 years, 2.6% – 60–69 years. Therefore, for generation, online learning technologies are less effective, but they should not be underestimated.

Users of this age are often ignored, although they have time on social media and a fairly stable financial resource in the form of pensions and benefits from children and grandchildren. These users want to feel important and monitor the activity of their younger family members. That's why they come to social networks. Family is the main value for Baby Boomers. Their success is directly correlated with the successful marriage and well-being of children and grandchildren. They also value youth, because, at the age of their adulthood, young people were associated with progress, a happy future, and strong opportunities. Baby Boomers subscribe to learning content, including favourites, less than other generations. However, these people are the most loyal learners. If they have already appreciated the learning content, they will always use it.

For Generation X, the convenience of learning, which saves time, as well as the ability to study many different fields of knowledge in one place are important. Individual learning is also important for this generation, they do not tolerate imposition and pressure, and they make their own learning decisions. They look for something unique in the learning content and decide according to the slogan "surprise me and I'll learn it". Accordingly, for this generation, the learning technology should be based on the uniqueness of its presentation. Generation X is an active Internet user. The convenience of online learning is important for them; they are active users of social media, so learning content in them is very effective. Also, they are active television viewers, radio listeners, and readers of the press, so learning content in these media is relevant to them.

Today, generation X tries to make up for lost money by getting competencies that help emphasize

Table 7: Defining learning activities as Web 1.0, Web 2.0, or Web 3.0 technologies.

Activity	WebTech
Reviewing information in graphic format	Web 1.0
Using search engines for online research	Web 1.0
Interacting with peers in social media forums	Web 2.0
Practising real-world interactions in online simulations	Web 1.0, 2.0, or 3.0
Reviewing quick reference guides such as FAQs	Web 1.0
Reading text (theories, concepts, non-fiction)	Web 1.0
Engaging in live short (one-hour) webinars	Web 2.0
Using mobile apps to engage in learning via smartphone	Web 3.0
Playing multiplayer online games within virtual worlds	Web 3.0
Participating in multiuser online brainstorming centres	Web 2.0 or 3.0
Completing questionnaires and/or surveys	Web 1.0
Participating in online discussion boards	Web 2.0
Observing people online (desktop-sharing)	Web 2.0
Sharing snippets of info online in Twitter-like communities	Web 2.0

their uniqueness. At the same time, it is very important for them to feel the possibility of choice. Such people are actively interested in politics, does not like too far-fetched content with a lot of slang, primitive humour irritates them. Clarity, conciseness, detailed instruction are very important for this generation. Therefore, they enjoy popular 'how-to' content, concise informative posts, life hacks and recipes. They also like to be nostalgic. Content that makes them nostalgic is popular. But before chose learning content they watch video reviews, read reviews, and research the site or web pages for a long time. It is important to note that such people are very loyal learners.

For Millennials / Generation Y, a learning environment is becoming a place not only for studying but also for entertainment. They value inner comfort, so do not make quick decisions. They like the variety of choices, the opportunity to try. This is the generation that watches little TV; reads books electronically. Generation Y today shapes social development trends and influences learning needs. They pay attention to learning content as a means of information, as well as emphasizes the value of communication. They live in a race mode – the success of their peers forces them to constantly learn something new.

Millennials value every minute of life. They often flip through the news feed on social networks, looking at friends' photo reports, interested in business content. For content to interest a millennial, it must be concise or at least give an idea of how long it will take to process it. Often the determining factor is the picture: the image of a special algorithm is likely to lead to a conversion than a few paragraphs of profession-al and literate text. Millennials are affected by content that contains real user reviews, previews, tips from friends, etc. But if the learning content is already liked by the millennial, he will subscribe to his page. Of all generations, millennials are the most 'digitized': in addition to smartphones, they actively use tablets and laptops. This generation is most often demanding service. If something doesn't work out, the millennial will share a sad experience on social media, tarnishing the learning technology reputation. It's the same if one of the friends of Generation Y told him about the bad service: a typical representative of the generation will abandon the learning technology, not going into who is right and who is not.

Generation Z spends a lot of time on the Internet and social media, and 27% say they feel uncomfortable if they do not have access to the Internet for more than an hour (the InMind agency in Ukraine). But they are interested in the Internet as entertainment – 60% go online for fun, and the focus is about 8 seconds (the InMind agency in Ukraine). Gen-Z prefers Instagram and YouTube – in other words, visual content is everything to them. The coolness of learning content or technology is a significant factor. They pay attention to what allows them to be stylish, fashionable, popular. Research shows that Generation Z responds well to pages that their friends already like, as well as to content that is tailored to their unique needs. Authority for this generation is given by bloggers and influencers. They teach Gen-Z about innovations in the field in which they are interested. The younger generation is not interested in politics. The only way to convey something serious to them is memes, infographics, illustrations and other content in the form of game entertainment.

Summarising the above generational differences in education, there are recommendations on how to attract the attention of each age group on learning content (table 8).

Understanding the particular needs of the learner at any given organization will help curriculum designers optimize web-based learning for the genera-

Table 8: The recommendations on how to attract the attention of each age group on learning content.

Generation	**Recommendations on how to attract the attention on learning content**
Baby boomers	hold interesting actions; simplify the content as much as possible, keeping it informative; there is no need to treat them as weak and helpless; let them feel their significance; appeal to family traditions.
Generation X	create the most informative content; make a how-to video and offer a list of life hacks; play on nostalgia, for instance, turn on the background music of the 70-80-s, depict popular stars of the time, use their quotes; allow feeling their uniqueness and superiority.
Generation Y	use quality photos and video content; add real feedback; think about personal time, note how long it takes to read content, how long the event will last; provide these people with impeccable service 24/7.
Generation Z	create up-to-date memes, infographics, images and other gamified content; seek and meet leaders of local Gen-Z people; take care of the environment and promote this idea in content strategy.

tionally diverse workforce, requiring flexibility and adaptability to create effective learning. The responsibility falls on the purveyors of information to be flexible. We no longer live in a top-down education system but must respond to student's needs and preferences with a variety of skills and a repertoire of learning strategies (Kriegel, 2013).

Thus, today it is no longer enough to use classic educational technologies. Achieving a significant effect requires a personalized approach that takes into account the values of different generations of learners.

5 CONCLUSIONS

We try to discuss the problem of learning environment development in the context of its technological evolution and educational influence. The principal difference between today learning environment and the previous one is its ability to react to student's learning activities and needs providing a personalized local learning environment. The proliferation of virtual forms for education is a natural stage in education evolution. It covers the whole system from the chalkboard to smartboard, from a usual library to an electronic one, from small training groups to virtual classrooms of any scale, etc. Virtual and traditional forms of education should not be perceived as mutually exclusive. A good education today is a synthesis of various forms of acquiring knowledge and modern technologies, the optimal combination of which only the student himself can determine for himself. The hybrid learning environment entered the XXI century as the most promising, synthetic and integral part of education. But the precise issue that the article addresses is a personalized approach to better understand the characteristics of users belonging to different generations. Using statistical analysis, we identify that there are users of four generations in the modern learning environment of an average university. Thus, the main part of university teaching staff can be made of Gen-X, Baby Boomers, Millennials/Gen-X and Silent Generation. Researches prove that Millennials stand out for their technology use, but older generations also embrace digital life. That's why understanding the generations' behaviour as the users of learning content allows providing the adequate attraction of EduTech for each age group of learners. The recommendations on how to attract the attention of each of the four generations (Baby Boomers, Gen- X, Gen-Y, Gen-Z) on learning content are made under the generational differences in education analysis.

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Structural Equation Modeling in Educational Research: A Case-study for PhD Training

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Abstract: The article deals with the problem of using structural equation modelling (SEM) methodology in educational research. It allows the researcher to build multidimensional models of the phenomena and processes that are being studied. The SEM methodology is based on many well-known methods such as correlation, regression, factor analysis, variance analysis and covariance analysis. The methodology is mainly based on deductive logic, involves the preliminary construction of a structural model of relationships between variables in order to further check for consistency with the experimental data. The article summarizes the use of various SEM software in the training of doctors of philosophy of the world's leading universities and provides an example of using the SEM methodology in educational research for PhD student training. An important point in preparing specialists for using SEM is to select or obtain the necessary data sets that are representative and valid. During the research the Ukrainian teacher's self-efficacy model with SEM methodology was checked, and the obtained results were compared with the research data of the worldwide teacher's survey – The Teaching and Learning International Survey (TALIS). The lower self-efficacy of Ukrainian teachers, especially in the student engagement block, was showed.

1 INTRODUCTION

1.1 Setting of a Problem

In recent years, many PhD programs were organized in Ukraine. Qualitative scientific research is impossible without a systematic description of the studied phenomena; multidimensionality of the investigated phenomena requires the use of multidimensional analysis methods that are capable to identify causal relationships, latent factors, etc. A promising area in the field of multidimensional applied analysis is the structural modeling or structural equation modeling, which is becoming an increasingly popular tool for researchers in the field of education, psychology and social sciences (Kline, 2015; Khine, 2013; Mitina, 2008; Nasledov, 2013; Chornyi, 2011).

In our article (Panchenko et al., 2021) the three focuses of the research component of doctoral program are proposed. The first focus relates to reproducible research principle. The second focus is related to the use of multivariate models of phenomena's study and SEM methodology. The SEM methodology is mostly based on deductive logic, involves the preliminary construction of a structural model of the relationships between the variables in order to further check for consistency with the experimental data. The third focus combines qualitative and quantitative methods and the use of triangulation (data triangulation, investigation triangulation, theory triangulation etc.). The content of selected courses for doctorate students is proposed: Reproducible Research and Multivariate Methods in Scientific Research courses.

In this article, we focus on the SEM methodology; we consider it very important to train future doctors of philosophy to use it in the educational research.

The popularity of the SEM methodology is evidenced by the experiment we conducted. At the request of "structural equation modeling" to search books on Amazon.com (as of March 16, 2013), we obtained 59 items, the graph of which is clearly shown in figure 1. In the center of the graph (figure 1, on

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the left), where 5 subgraphs can be observed, there is the third edition of the bestseller, Principles and Practice of Modeling by Structural Equations by Kline (Kline, 2015). The companion site of this publication provides methodological support and offers download syntax, data and source files for all sample books for execution in three environments EQS, LISREL and Mplus, and a comparison of simulation results. A similar experiment, conducted on March 28, 2019 (figure 1, on the right), shows interest growth in structural modeling; we have 157 items. Interestingly, the fourth edition of the same bestseller has the biggest rating there.

Figure 1: Books on " structural equation modeling", Amazon.com, year 2013 versus 2019.

While solving the scientific problem of training PhDs to use the SEM methodology, the following main results were obtained in past author works: the content of the simulation training by the structural equations of specialists in the field of education is revealed; the dynamics of software simulation by structural equations is analyzed; the necessity of including these means in the courses for students and graduates of higher educational institutions of Ukraine that specialize in the field of education and social sciences is substantiated (Panchenko, 2013).

The syllabuses of PhD SEM courses of leading universities are analyzed (Higher School of Economics, St. Petersburg; University of Amsterdam; University of Vaasa, Finland; University of Mannheim; Iowa State University; Brown University; University of Leuven; School of Education University of Pittsburgh; Oslo University etc).

An analysis of the best PhD programs in sociology according to the Princeton Review's "Gourman Report of Graduate Programs" (Plous, 2021) showed that they must have courses on structural equation modelling. In table 1, we summarize the use of various SEM software in the training of doctors of philosophy of the world's leading universities.

Analysis of syllabusis (table 1) showed that in general the courses are organized in the format of seminars. The main activity is created at the intersection of lectures, group discussions, software application and interpretation of results. Teaching materials are available through the Blackboard or Moodle learning management system. The number of course credits ranges from 1 to 6 with 1–3 credits for introductory courses, and 4–6 credits for advanced. Courses are offered as part of the training of doctors of philosophy in the field of pedagogy, psychology, sociology, statistics, information systems and business, public health, sports, etc. Both proprietary and free software is used. In most courses, one software tool is acting as the main tool, and another one as an additional. But there are courses in which several software tools are widely used.

Here is an example of evaluating the work of students in the course (www.soc.iastate.edu, 2021). Homework with the use statistical software: 8%; critical review of articles on the topic (4 reviews of 4–5 pages): 30%; statistical analysis (4 reports of 12–15 pages): 62%. For a critical review, the parameters of its evaluation are given: for example, to explain the basic model that the author evaluates (20% of the mark); discussion of critical mistakes made by the author (40%); an explanation of how the casual effect (40%) can be correctly estimated. Some programs offer an exam and a final project during the course as their own mini-study on the use of SEM.

The objectives of the SEM courses are defined as follows: using structural equation modeling methodology to study the problems of social and behavioral science, understanding the strengths and flaws of the method and its limitations, teaching methods of assessment, identification models, testing their validity, interpretation, critical evaluation of scientific publications on this subject, using statistical software to perform structural equation modeling analysis, preparation of research reports in accordance with the standards of research (Panchenko and Razoronova, 2016).

In preparing specialists for using SEM an important point is to select or obtain the necessary data sets that are representative and valid. We offer our students the survey data from Ukrainian teachers (Shchudlo et al., 2018; TALIS, 2017; Questionnaires, 2017).

On August 31, 2017, the Ukrainian Association of Educational Researchers completed the All-Ukrainian monitoring "Teaching and Learning Survey on Principals and Teachers of Secondary Education Institutions" (based on the TALIS methodology (OECD, 2018). The study was conducted within the framework of the project "Teacher" and "Education Reform: Quality Assessment in an International Context", which is implemented by the All-Ukrainian Foundation "Step by Step" with the support of the Ministry of Education and Science of Ukraine (Shchudlo et al., 2018). The study was attended by

Table 1: Software in SEM courses.

Course name	Software						
	AMOS SPSS	EQS	Mplus	Lisrel	Open Mx	SAS	R
”Modern Social Analysis”, HSE, St. Petersburg			+				
”Structural equation modelling in educational research”, University of Amsterdam			+	+	+		
”Latent Structural Equation Modeling”, University of Vaasa, Finland	+		+	+		+	+
SEM1, University of Oregon	+		+				
”Structural equation modelling using LISREL and EQS” (SEM PhD workshop)		+		+			
”Structural Equation Modeling in the IS Discipline”, University of Mannheim	smart PLS						
”Structural equation models for social and behavioral research”, Iowa State University							
”Structural Equation Models in the Social Sciences”, University of Brown				+			
”Causal analysis and structural equation modeling”			+ Stata				
”Structural Equations”, University of Leuven, PhD in Statictics				+			
”Structural Equation Modeling”, School of Education University of Pittsburgh			+		+		
”Structural equation modeling: Longitudinal models and multi-group models”, University of Oslo			+				
”Building and Testing Structural Equation Models In the Social Sciences”, University of Michigan	+	+		+			
”An introduction to structural equation modelling”, Doctoral college of Ulster University							
”PhD-M: Structural Equations Modeling”, University of Vienna				+			
PSY9140 -– ”Structural Equation Modelling”, Oslo university			+				+
PSY8006 — ”Introduction to Structural Equation Modeling (with MPlus)”, Norwegian university of science and technology			+				
Introduction to Structural Equation Modeling (Sem), PhD School of Copenhagen Business School			+				
Structural Equation Modeling, HSE, Russia							+

3,600 teachers and 201 school principals from 201 schools, representing all regions of Ukraine. The results of the study, according to the OECD policy, are open and accessible.

The purpose of our article is to show the ways to apply the SEM methodology in educational research for PhD students. In our case-study, we will, based on the survey data of Ukrainian teachers, check the model of teacher’s self-efficacy with SEM methodology, and compare obtained results with the research data of the worldwide teacher’s survey – TALIS.

1.2 Related Works

The methodology of structural modeling has received wide recognition in the global community. The study of the basics of structural modeling has become a component of the training of researchers specializing in social sciences (Panchenko and Razoronova, 2016). In Russia, the ideas of structural modeling in relation to psychology are reflected in (Mitina, 2008; Nasledov, 2013). The use of SEM with an emphasis on economic research has been studied by Chornyi (Chornyi, 2011). Unfortunately, in Ukraine, structural modeling is not sufficiently used in educational and social studies in general, and in the training of researchers at universities, in particular.

The aspects of the application of the SEM methodology to educational data (TALIS, 2013) are devoted to the following research. A structural equation model of determinants of the perceived impact of teachers' professional development (the Abu Dhabi application) is reviewed by Badri et al. (Badri et al., 2017). How school context and teacher's characteristics predict distributed leadership is presented by Liu et al. (Liu et al., 2018). The invariance of teachers' sense of self-efficacy measured across countries is reviewed by Scherer et al. (Scherer et al., 2016).

2 RESULTS OF THE STUDY

TALIS (Teaching and Learning International Survey) is one of the most prestigious international comparative education projects. The project is dedicated to studying the environment and work conditions of school teachers. It has been implemented since 2008 by a research consortium under the Organization for Economic Cooperation and Development (OECD). 24 OECP countries and partner countries participated in the first wave of TALIS study in 2008, 34 – in the second wave in 2013, and 44 countries plan to participate in 2018 (Shchudlo et al., 2018; OECD, 2018).

All-Ukrainian monitoring survey of teaching and learning among school principals and teachers of general educational institutions (according to the methodology All-Ukrainian research on TALIS methodology) is an example of use of international instruments for studying national educational space and identifying the place of the Ukrainian teacher community in the international community educational context. The purpose of the research is to identify and analyze socio-demographic and professional characteristics of Ukrainian teachers and academic staff and the environment of schools on the basis of reliable comparable metrics (Shchudlo et al., 2018).

3600 teachers of 5–9 grades of secondary schools (level ISCED 2) and 201 school principals from 201 schools participated in the survey in 2017. Error of simple random sampling is 1.6%, the school sample selection error takes into account design effect is 2.3%.

From the Ukrainian teacher's survey file (TALIS, 2017) we selected 3477 lines without missing values for 12 variables that represented the teacher's self-efficacy (table 2).

Bandura (Bandura, 1982) defines self-efficacy as a personal judgment of "how well one can execute courses of action required to deal with prospective situations". He names four sources of efficacy beliefs: 1) mastery experiences; 2) vicarious experiences; 3) verbal persuasion; 4) emotional and physiological states.

Professional teacher's self-efficacy, in general, is the perception of a person's own ability to mobilize motivation, cognitive resources and behavioral activity that are needed to control the situation in order to achieve the intended purpose (Bandura, 1982; Kremeshna, 2010; Krasnoryadtseva et al., 2014).

TALIS model for teacher consists of three components of self-efficacy: self-efficacy in classroom management; self-efficacy in instruction; self-efficacy in student engagement.

We will conduct a factor analysis for these data. The obtained values of Kaiser-Meyer-Olkin (0.902) and Bartlett's Test of Sphericity (13308, $p < 0.001$) indicate that factor analysis is a suitable method for these data. The scree plot below shows three factors (figure 2).

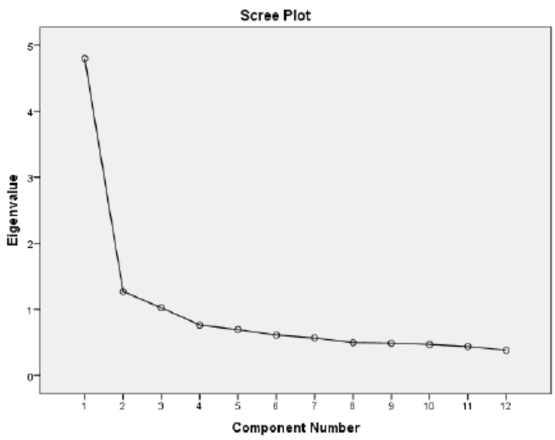

Figure 2: Scree plot: a line plot of the eigenvalues of factors.

Let us consider the rotated component matrix (table 3). It demonstrates that the first factor, loading high factor weight of the attributes, is related to the class management, the second one is related to the student's engagement, and the third one to the instruction.

You can also observe that the variable "Craft good

Table 2: Variables of teacher's self-efficacy.

Variable name	Content
TT2G34A	Get students to believe they can do well in school work
TT2G34B	Help my students value learning
TT2G34C	Craft good questions for my students
TT2G34D	Control disruptive behavior in the classroom
TT2G34E	Motivate students who show low interest in school work
TT2G34F	Make my expectations about student behavior clear
TT2G34G	Help students think critically
TT2G34H	Use a variety of assessment strategies
TT2G34I	Provide an alternative explanation, for example, when students are confused
TT2G34J	Implement alternative instructional strategies in my classroom
TT2G34K	Get students to follow classroom rules
TT2G34L	Calm down a student who is disruptive or noisy

Table 3: Rotated component matrix.

	Factor 1: Class management	Factor 2: Student Engagement	Factor 3: Instruction
Control disruptive behavior in the classroom	.795		
Calm a student who is disruptive or noisy	.773		
Get students to follow classroom rules	.765		
Make my expectations about student behavior clear	.596		
Help my students value learning		.816	
Get students to believe they can do well in school work		.764	
Motivate students who show low interest in school work		.644	
Help students think critically		.448	
Craft good questions for my students		.443	
Provide an alternative explanation, for example, when students are confused			.785
Implement alternative instructional strategies in my classroom			.736
Use a variety of assessment strategies			.730

questions for my students" is more related to the factor "Student engagement" than the factor "Instruction". As you see, three factors explain 59.1% of variability (table 4).

Table 4: Total variance explained.

Component	Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	2.571	21.425	21.425
2	2.313	19.274	40.698
3	2.211	18.429	59.127

Scientists identify next five steps in SEM application (Kline, 2015; Nasledov, 2013).

1) model formation. The model depicts the graphical views of the researcher about the structure of the variable and latent constructs of ties. At the same time, they decide which parameters should be fixed, and which should be left free.
2) model identification
3) model evaluation
4) checking the consistency of the model
5) model correction by adding new links and eliminating insignificant links.

Let us build a model of confirmatory factor analysis with AMOS SPSS (figure 3).

You can see the resulting teacher's self-efficacy model in the figure 4.

We got the following results. Number of distinct sample moments: 78; number of distinct parameters to be estimated: 27; degrees of freedom: 78–27=51. Criteria for coherence RMSEA $0.07 < 0.08$, that is, the model is consistent with the data.

Using the data (Shchudlo et al., 2018), we clearly compared the indicators of self-efficacy of teachers in Ukraine and in the world (table 5, figure 5). The graph shows that self-efficacy of Ukrainian teachers

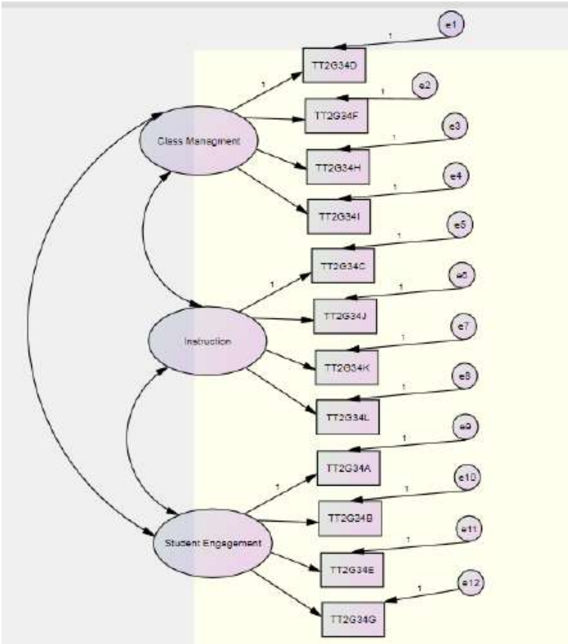

Figure 3: Initial teacher's self-efficacy model in AMOS SPSS.

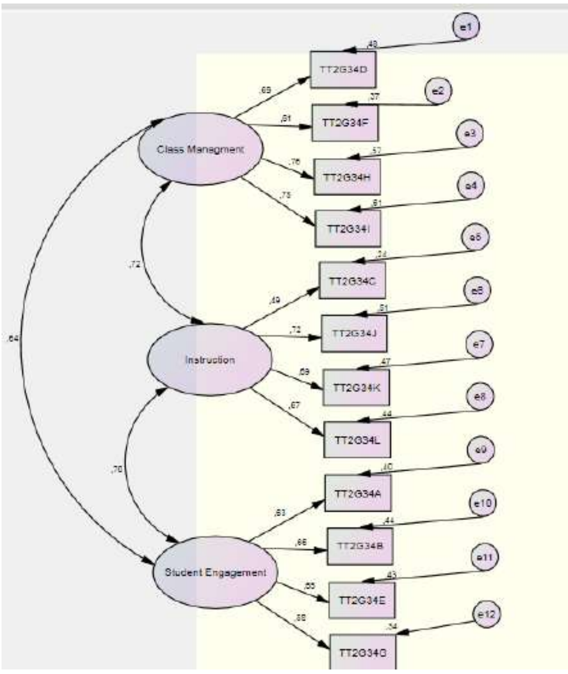

Figure 4: Resulting teacher's self-efficacy model in AMOS SPSS.

is lower, especially in the student engagement block (variable "Get students to believe they can do well in school work" – difference was 26.4%, "Help my students value learning" – 26%, "Motivate students who show low interest in school work" – 19.4 %).

As a continuation of the research, PhD students

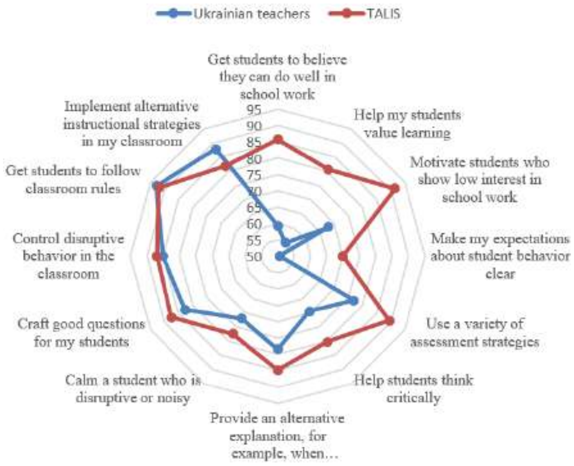

Figure 5: Comparison of teachers' self-efficacy in Ukraine and in the world.

can be invited to analyze the results of a recently published survey TALIS 2018. TALIS 2018 (Plous, 2021) identifies a number of factors that are related to teacher self-efficacy:

1. Teacher characteristics: years of experience as a teacher
2. Index of classroom disciplinary climate
3. Took part in any induction activities at current school
4. Induction activities at current school included team teaching with experienced teachers
5. Professional development acitivities in the 12 months prior to the survey did have a positive impact on teaching practice
6. Index of workplace well-being and stress
7. Fixed-term contract: less than or one school year
8. Index of professional collaboration
9. Index of target class autonomy

This relationship does not apply to all countries (table 6).

An interesting task for PhD students is to build the SEM model taking into account factors of teacher's self-efficacy according TALIS 2018.

3 CONCLUSIONS AND PERSPECTIVES OF FURTHER RESEARCH

Measurements that are used in modern educational research are becoming more and more complex. The author's vision of the research component of training

Table 5: Indicators of self-efficacy of teachers in Ukraine and in the world (%).

Variables	**Ukrainian teachers**	**TALIS**	**Difference**
A. Get students to believe they can do well in school work	59.4	85.8	26.4
B. Help my students value learning	54.7	80.7	26
C. Craft good questions for my students	82.6	87.4	4.8
D. Control disruptive behavior in the classroom	85	87	2
E. Motivate students who show low interest in school work	50.6	70	19.4
F. Make my expectations about student behavior clear	68	91.3	23.3
G. Help students think critically	69.5	80.3	10.8
H. Use a variety of assessment strategies	77	89.4	12.4
I. Provide an alternative explanation. for example. when students are confused	78.5	84.8	6.3
J. Implement alternative instructional strategies in my classroom	87.8	81.9	-5.9
K. Get students to follow classroom rules	92.9	92	-0.9
L. Calm a student who is disruptive or noisy	72	77.4	5.4

Table 6: Factor of self-efficacy of teachers in TALIS 2018 and number of countries and percentage of countries with positive and negative relation (%).

Factor	**N+**	**%+**	**N-**	**%-**
Teacher characteristics: years of experience as a teacher	29	60.4	0	0
Index of classroom disciplinary climate	0	0	45	93.8
Took part in any induction activities at current school	25	52.1	0	0
Induction activities at current school included team teaching with experienced teachers	35	72.9	0	0
Professional development acitivities in the 12 months prior to the survey did have a positive impact on teaching practice	33	68.8	0	0
Index of workplace well-being and stress	0	0.0	42	87.5
Fixed-term contract: less than or one school year	0	0.0	15	31.3
Index of professional collaboration	46	95.8	0	0
Index of target class autonomy	47	97.9	0	0

PhD students focuses on three areas: reproducible research; multivariant analysis and SEM methodology; triangulation (Panchenko et al., 2021). SEM methodology helps researcher determine the effectiveness of educational innovations in different educational contexts, as well as model and study phenomena in their interrelations; understand the influence of latent factors, develop systemic and critical thinking.

An important point in training specialists to use SEM is to select or obtain the necessary data sets that are representative and valid. For example, we offer our students such data: All-Ukrainian survey data from Ukrainian teachers. The main criteria for choosing it are: 1) an array of data is freely accessible, 2) it is large (contains 3600 lines), 3) it is accompanied by supporting documentation, 4) the array and documents have Ukrainian and English versions, 5) the array variables are simple and understandable, 6) it is possible to conduct comparative studies with the data of the International Talis Teacher's Survey.

During the case study the teacher's self-efficacy model using SEM methodology were checked, the obtained results were compared with the TALIS survey data (2013). The research demonstrated that self-efficacy of Ukrainian teachers, especially in the student engagement block, was lower.

Further development of work in this direction is the creation of teaching and methodological support for modeling by structural equations in the form of a computer workshop in the AMOS and R environments for the training of researchers in the field of pedagogy and social sciences and a proposal to include SEM in higher education research.

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Cloud Labs as a Tool for Learning Cisco CyberSecurity Operations and DevNet Associate Fundamentals Courses

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Abstract: The article is devoted to the study of the problem of using the corporate cloud of the university in the process of studying some courses of the Cisco Network Academy. Today, many universities have similar academies, while others can open them. Based on the free software platforms Apache CloudStack and EVE-NG Community Edition, the authors have developed and implemented 2 cloud labs. One of them is designed to teach the course "CCNA CyberOperations", and other is "DevNet Associate Fundamentals Courses". Both laboratories work on the IaaS model. Thanks to the technology of built-in virtualization, the work of many virtual machines, storage of their state, traffic analysis and visualization of network topologies is supported. The article describes the experience of teaching students majoring in "Secondary Education. Computer Science". The authors conducted a survey of students who studied in the courses. The purpose of the survey was to determine how satisfied the learners were with the course. Statistical processing of the results was performed based on the Rasch model using MiniSteps software and R language. Students highly rated on-line curriculum materials, access to virtual machines, clear and easy to understand lessons, presenting information in multiple ways.

1 INTRODUCTION

Currently, the problem of intensifying the training of future professionals is relevant. This problem is especially relevant for the process of teaching computer science teachers (Ponomareva, 2021). This is because the effectiveness of this process is the basis for preparing future generations for life in the global digital world.

Various studies prove that the improvement of learning is possible through the use of e-learning systems (Kuzminska et al., 2019; Vlasenko et al., 2020). However, these tools alone are not enough. Among the factors influencing the low effectiveness of the introduction of e-learning is the lack of independent work of students.

Today, the development of computer systems and networks provides universal access to educational resources. This led to the emergence of the concept of open education (Kukharenko and Oleinik, 2019). One of its modern tools is massive open online courses (MOOC – Massive Open Online Cources) (Zinovieva et al., 2021).

One way to solve this problem is to study open courses by students. Their advantages are as follows: the opportunity to study at a convenient time; the ability to compare teaching styles and materials of different courses; the experience in discussing and peer assessment; improving the skills of listening, reading and writing English (or other); reflection of their own pedagogical activity in the light of new ideas, the digital creativity and collaboration with other participants (Markova et al., 2018).

Cisco offers similar courses within Cisco Network

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Academy. Although these courses do not fully correspond to the ideology of the MOOC, Cisco Network Academy can be organized at any education institute. Cisco Networking Academy, a Cisco Corporate Social Responsibility Program, is an IT skills and career building program available to educational institutions and individuals worldwide. Today, the company is professing a paradigm for providing free access to some courses to a wide range of users.

For example, scientists at The Open University of the United Kingdom have integrated some Cisco Network Academy courses into the training process of computer science bachelors. The researchers substantiated the effectiveness of the developed environment and identified the key role of the instructor in teaching students. A constructivist approach and blended learning model were applied during the design and testing of the course. It has proven to be an effective way to conduct Cisco courses. Such conclusions of authors are confirmed by the positive feedback of students and their academic achievements (Moss and Smith, 2010).

These and other studies confirm that Cisco Network Academy courses can be used effectively in the study of computer sciences. This raises the problem of giving students access to the objects of study. This problem is especially relevant in courses on cybersecurity and network applications development. The solution to this problem is possible through the introduction of cloud technologies for virtualization of objects of study in the courses of the Cisco Network Academy.

The goal of this article is to describe the model of cloud labs as learning tools in Cisco CyberSecurity Operations and DevNet Courses and to research the feedbacks of students about such labs.

2 RESULTS

As the experience of a secondary school shows, a teacher of informatics is the leading ICT specialist (Kuzminska et al., 2019). In the context of providing information security (Savchenko et al., 2020), he must be able to balance the advantages and disadvantages of using digital technologies in the learning process. We suggest using Cisco Network Academy Courses to improve the training process for future computer science teachers. At the same time there are problems with the provision of learning tools. Cisco Network Academy offers several solutions to the problem, such as:

- Use simulators like Cisco Packet Tracer. This approach is usually offered in courses related to the study of computer networks. The simulator is quite a powerful and affordable tool, but it simulates only the basic functionality of network devices.
- Work with online and cloud services. For example, this approach is used in programming courses to access API functions. However, these services may change. As a result, course authors need to constantly monitor changes and adjust learning objectives.
- Deployment virtual machines. In this case, the training takes place in an artificially created environment, which is created specifically for this course and contains all the necessary tools.

It should be noted that the Cisco Network Academy courses use each of the approaches. In the context of our study, we will examine the latter approach. We used virtual machines in CCNA Cyber Operations and DevNet courses. Having analyzed the available free courses, we chose CCNA Cyber Operations (Cisco, 2019) as a basic course for formation teachers' cybersecurity competences. By the end of this course, the students will be able to:

- Install virtual machines to analyzing cybersecurity threat events.
- Explain the role of the Cybersecurity Operations Analyst in the enterprise.
- Explain the Windows and Linux OS features to support cybersecurity analyses.
- Analyze the operation of network protocols and services.
- Classify the various types of network attacks and identify network security alerts.
- Use network monitoring tools to identify attacks against network protocols.
- Use various methods to prevent malicious access to computer networks.
- Analyze network intrusion data to verify potential exploits.
- Apply incident response models to manage network security incidents.

The course contains the following chapters: Cybersecurity and the Security Operation Center, Windows OS, Linux OS, Network Protocol and Services; Network Infrastructure, Principles of Network Security, Network Attacks: A Deep Look, Protection the network, Cryptography and the Public Key Infrastructure, Endpoint Security and Analysis, Security Monitoring, Intrusion Data Analysis, Incident.

To our opinion, the material of some chapters can be considered in other courses (Operation Systems, Computer Networks, Cryptography, etc.). Another approach is to include these chapters in the content of mentioned courses.

Each chapter contains terms and concepts review, quiz, labs and exam. In the process of teaching the course, we met with the problem of organizing laboratory works. Cisco Network Academy offers to run them on virtual student machines. This approach is justified, but it limits the universal and everywhere access of students to study. The use of separate virtual machines does not ensure the cooperation of students between themselves and with the teacher.

An effective way to overcome these limitations is to use the cloud technologies. Bykov and Shyshkina (Bykov and Shyshkina, 2018) note that the development of cloud computing technologies, adaptive information and communication networks services, virtual and mobile learning facilities are the important step towards solving the problems of accessibility and quality of training. Application of cloud technologies in professional activities should correspond the requirements of fundamentalization of learning through the inclusion in the content general both the theoretical and the technological provisions, with demonstration of them on the concrete examples (Merzlykin et al., 2017; Bondarenko et al., 2019; Lovianova et al., 2019; Spirin et al., 2019). Glazunova and Shyshkina (Glazunova and Shyshkina, 2018) distinguishes the following levels of the University Cloud-based Learning and Research Environment: physical, level of the virtualization and virtual resource management, as well as platforms and software levels.

We deployed a cloud-based environment according to the IaaS model. In the environment, the public and private cloud platforms are integrated. Since the corporate cloud platforms are widely using the virtualization technology, we see as possible the deployment of cloud laboratories on their basis.

After analyzing the interpretation of Bykov et al. (Bykov et al., 2020), we note that the cloud laboratory is an information system in which network virtual ICT objects are formed thanks to a special user interface, which is supported by the system software of the network setting. Such objects are an integral part of a logical network infrastructure with a flexible architecture that, according to its structure and time, corresponds to the personality needs of the user.

Cornetta et al. (Cornetta et al., 2019) have investigated how digital fabrication laboratories can leverage cloud technologies to enable resource sharing and provide remote access to distributed expensive fabrication resources over the Internet. They deployed a cloud lab according to the new Fabrication as a Service (FaaS) model. Researchers have developed firmware and software for monitoring equipment and providing real-time communications.

Gillet and Li (Gillet and Li, 2015) explore the concept of cloud laboratories as common spaces that integrate applications. Researchers are also studying the problem of integrating MOOC into the learning environment. They note that cloud labs can enable the implementation of connectivist MOOCs, allowing teachers or students to collect and monitor the use of openly available learning resources.

Typically, in a cloud laboratory, information from a subject field is based on some facts, and therefore limited by a set of predicted experiments. Another approach suggests that a pupil or student is able to carry out any experiments, not limited to a previously prepared set of results. It is thanks to the use of the virtualization technology of operating systems, the last approach should be tried to implement in the designed laboratory. Cloud virtualization technologies provide unique opportunities for the learning organization of the Cisco CyberSecurity Operations course.

The designed virtual laboratory was implemented in the cloud-based learning environment of Volodymyr Hnatiuk Ternopil National Pedagogical University. Based on the comparative analysis [8], as the program basis of the laboratory, we have chosen the Apache CloudStack platform. Then we modified the Cloud-based Learning Environment so that students could create virtual networks. This networks should not require changes in the topology of physical networks in the academic cloud. We divided the traffic transmitted between students' virtual computers among 100 VLANs. So each student has an opportunity to store their virtual computers and other devices in their personal or several guest networks.

As Apache CloudStack does not provide tools for visualization of network structure, students often have difficulty in designing and configuring networks in a cloud infrastructure. That fact prompted us to integrate into a virtual cloud laboratory a system that makes it possible to visualize the process of network design. It was vital that such system could work with networks on Apache CloudStack virtual machines. We analyzed relevant publications and compared several platforms – Cisco packet tracer, Graphical Network Simulator (GNS), Unetlab (EVE-NG). Despite the benefits of Cisco packet tracer, it did not provide the performance of all tasks of the laboratory works. Among the platforms of GNS and EVE-NG, we have chosen the last.

Every student's copy of ENE-NG platform is a separate virtual machine in Apache CloudStack cloud. As each node of EVE-NG is itself a virtual machine, hosts integrated in Apache CloudStack infrastructure have to support nested virtualization.

The laboratory works involves the use of such virtual machines: CyberOps WorkStation (based on Arch Linux); Kali Linux; Security Onion (based on Ubuntu Linux); Metasploitable; Windows Client.

The students used a virtual cloud laboratory when performing the following laboratory works:

1. Chapter 2: Windows Operating System. 2.0.1.2 Lab – Identify Running Processes; 2.1.2.10 Lab – Exploring Processes, Threads, Handles, and Windows Registry; 2.2.1.10 Lab – Create User Accounts; 2.2.1.11 Lab – Using Windows PowerShell; 2.2.1.12 Lab – Windows Task Manager; 2.2.1.13 Lab – Monitor and Manage System Resources in Windows.
2. Chapter 3: Linux Operating System. 3.1.2.6 Lab – Working with Text Files in the CLI; 3.1.2.7 Lab – Getting Familiar with the Linux Shell; 3.1.3.4 Lab – Linux Servers; 3.2.1.4 Lab – Locating Log Files; 3.2.2.4 Lab – Navigating the Linux Filesystem and Permission Settings.
3. Chapter 4: Network Protocols and Services. 4.1.1.7 Lab – Tracing a Route; 4.1.2.10 Lab – Introduction to Wireshark; 4.4.2.8 Lab – Using Wireshark to Examine Ethernet Frames; 4.5.2.4 Lab – Using Wireshark to Observe the TCP 3-Way Handshake; 4.5.2.10 Lab – Exploring Nmap; 4.6.2.7 Lab – Using Wireshark to Examine a UDP DNS Capture; 4.6.4.3 Lab – Using Wireshark to Examine TCP and UDP Captures; 4.6.6.5 Lab – Using Wireshark to Examine HTTP and HTTPS;
4. Chapter 7: Network Attacks. 7.0.1.2 Lab – What is Going On? 7.3.1.6 Lab – Exploring DNS Traffic; 7.3.2.4 Lab – Attacking a MySQL Database; 7.3.2.5 Lab – Reading Server Logs; Chapter 9: Cryptography and the Public Key Infrastructure; 9.0.1.2 Lab – Creating Codes; 9.1.1.6 Lab – Encrypting and Decrypting Data Using OpenSSL; 9.1.1.7 Lab – Encrypting and Decrypting Data using a Hacker Tool; 9.1.1.8 Lab – Examining Telnet and SSH in Wireshark; 9.1.2.5 Lab – Hashing Things Out; 9.2.2.7 Lab – Certificate Authority Stores;
5. Chapter 12: Intrusion Data Analysis. 12.1.1.7 Lab – Snort and Firewall Rules; 12.2.1.5 Lab – Convert Data into a Universal Format; 12.2.2.9 Lab – Regular Expression Tutorial; 12.2.2.10 Lab – Extract an Executable from a PCAP; 12.4.1.1 Lab – Interpret HTTP and DNS Data to Isolate Threat Actor; 12.4.1.2 Lab – Isolated Compromised Host Using 5-Tuple.

A typical topology of the network for the laboratory works is showed in figure 1.

Each of these machines was available in a cloud-based infrastructure. As a result, students could work with virtual machines in the university's local network or through VPN. The course was taught in a mixed methodology. It was dominated by independent distance work of students. The teacher's consultations were carried out at the classroom and online.

We have deployed a cloud lab for the Cisco DevNet Associate Fundamentals course. The course is dedicated to the development of competencies for a IT professionals, empowering organizations to embrace the potential of applications, infrastructure for the network, Internet of Things (IoT), Webex, etc. The course is also good because it can be completed by students with low levels of programming skills The DevNet course has the following modules:

1. Introduction. The module is devoted to the organization of the learning environment. Since students will be working in a cloud lab, we have modified this section a bit. In particular, they explained how to deploy a VM, what its parameters should be specified, how to connect to it remotely.
2. The DevNet developer environment. There are opportunities to learn more through such features as: learning labs, sandboxes, developers' documentation and support.
3. Software Development and Design Content. The software development life cycle is the main concept of this module. A phases of this process are also discussed in the module.
4. Understanding and Using APIs. In this module, students study API Design and Architectural Styles. The REST API is presented in more detail
5. Introduction to Network Fundamentals. The basic concepts of computer networks based on models OSI and TCP/IP are considered in this module.
6. Application Deployment and Security. Students are introduced to application deployment models such as virtual machines, containers, and serverless computing.
7. Infrastructure and Automation. In this topic students use a code to configure, deploy, and manage applications together with the compute, storage, and network infrastructures and services.
8. Cisco Platforms and Development. The module will be useful for students to further their career development. The topic describes Cisco Dev Centers. Those Dev Centers are a convenient way of grouping technologies together.

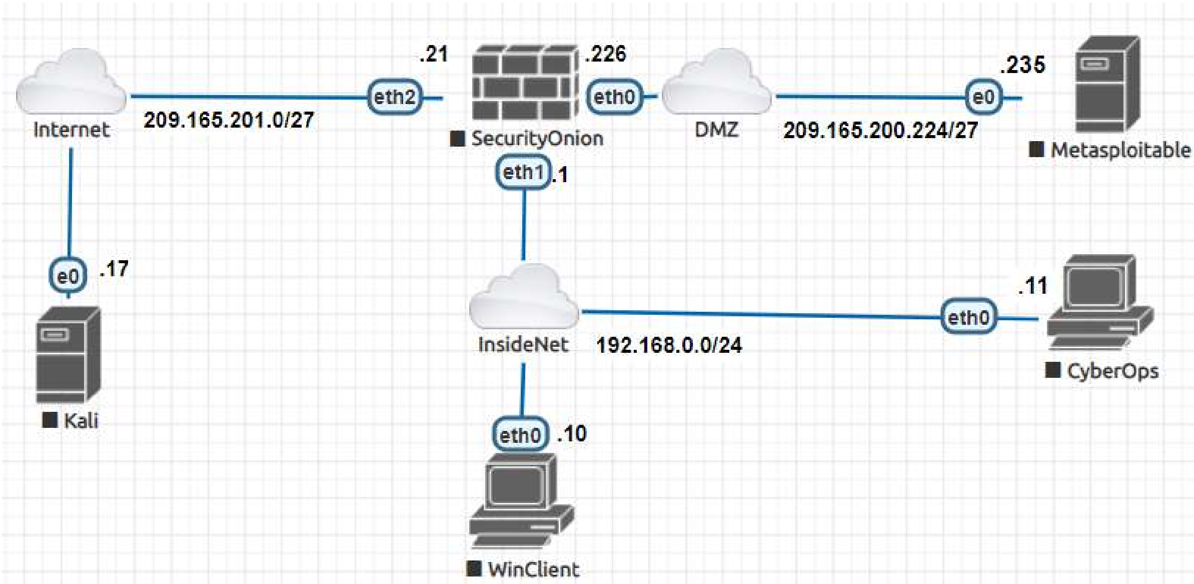

Figure 1: The network topology for labs.

The course offers to use a virtual machine based on free VirtualBox software. However, we modified it and created a VM template for the Apache CloudStack platform.

The VM runs on Ubuntu Linux and includes the following learning tools: interpreter of Python programming language, Visual Studio Code IDE, Postman (The Collaboration Platform for API Development), command-line utility Git, Cisco Packet Tracer, etc.

For example, VM was used to create a chatbot in the laboratory work “Integrating a REST API with Python”. Students used the REST-API to work with MapQuest, ISS Location and Webex Teams. Chatbot read messages from the Webex Teams room in JSON format, performed their parsing, found messages with the name of the city. In the next step, the script called the API of the MapQuest service to determine the geographical coordinates of the city. Another step was to determine the nearest time for observation of the International Space Station in this city. In the last step, the chatbot sent a reply message to the Webex Teams room.

After learning this courses, students completed the final exam. He contained 60 questions from all the topics of the course, as well as the fragments of laboratory works. 56 students majoring in “Secondary education. Computer Science” passed the exam. Of these, only 24 passed the exam successfully. This indicator can be explained by the fact that the course “Cyber Operations” was studied as optional and did not affect the student’s rating at the university.

In addition to the final exam students responded to the questionnaire “Cyber Operations Course Feedback”. Questionnaire questions were formulated according to the principle of the Likert scale (five response categories) and grouped in 5 blocks (table 1).

3 STATISTICAL ANALYSIS OF RESEARCH DATA

To evaluate the efficiency of the designed and deployed cloud-based labs, a model with equally distributed responses of all indicators on the scale of the latent variable was used. This is one of the models of the Rasch’s family, which is used in the case of polithomus indicators.

In the modern Item Response Theory (IRT), Rasch’s model allows us to assess the meaning of latent variables, to investigate the relationship between them, and to identify factors that influence the behavior of latent variables. IRT is based on the theory of latent-structural analysis: the final score is considered as a result of the combined interaction of latent parameters – the true level of preparation of students and the complexity of the questions (tasks). This approach to the evaluation of the studied features in IRT theory differs significantly from the classical test theory, in which the result is the final score in a particular survey, corrected for error.

The Rasch’s model is interpreted as a model of “objective measurements” that do not depend from the respondents and measuring instruments. The Rasch’s model is based on three assumptions (Bond

Table 1: List of distractors (items) in questionnaire.

Distractor	Code	Description
Please rate your level of satisfaction with the following aspects of this course (Course Satisfaction)	CS1	On-line Curriculum Materials
	CS2	Labs
	CS3	Access to Equipment/Software
	CS4	Classroom Instruction
	CS5	Assessments
Please rate how confident you feel in your ability to do each of the following (Confident Ability)	CA1	Explain the role of the Cybersecurity Operations Analyst
	CA2	Explain the Windows and Linux OS features and characteristics needed to support cybersecurity analyses
	CA3	Explain the operation of the network infrastructure and various types of network attacks
	CA4	Analyze the operation of network protocols and services, and identify attacks against them
	CA5	Use various methods to prevent malicious access to computer networks, hosts, and data
	CA6	Explain how to investigate endpoint vulnerabilities
	CA7	Evaluate network security alerts and identify compromised hosts and vulnerabilities
Compare your instructor to other instructors you have had in terms of: (Compare instructor)	CI1	Preparedness to teach the course
	CI2	Clear and easy to understand lessons
	CI3	Approachability with questions and ideas
	CI4	Presenting information in multiple ways
	CI5	Making the topic interesting
Please rate how much you agree with the next statements (Course Content)	CC1	The lab activities helped me to achieve the stated course objectives
	CC2	The exam scores reflected my understanding of the curriculum
	CC3	Having access to equipment helped me learn
	CC4	The course curriculum was technically accurate
To what extent did this course help you (Course Purpose)	CP1	Prepare for Certification exam(s)
	CP2	Learn skills that can be used in a future job
	CP3	Increase your value in the job market
	CP4	Obtain a new job or advance in your current job

et al., 2021):

1. The level of difficulty of tasks and the level of preparedness of persons being tested can be measured in one scale, with a common standard unit of measurement.
2. In the presence of such a scale the probability of the correct answer of the tested person depends on the difference between his level of preparedness and the level of complexity of the test task.
3. The outcome of the confrontation of the tested person with the test tasks can be predicted. If the level of preparedness of the tested person is higher, than the probability of his correct answer to the task of a fixed level of complexity should be higher.

To measure the complexity of tasks and level of knowledge, the unit of measurement, called logit, is used. In our research, we used the WINSTEPS program. The program is commercial, but its free version called MINISTEP. It allows you to use all the capabilities of WINSTEPS, but has a limit on the number of questions in the test (25) and the number of people (75) (WINSTEPS, 2019).

Standardized Residuals in the Rasch's model are modeled for normal distribution. Therefore, significant deviations from the value of "0" for the Mean and the value "1" for the Standard Deviation (SD) signal that the primary data do not correspond to the Rasch's model, which should correspond exactly to the normal distribution. In our study, the values Mean = -0.02 and SD = 1.03 are sufficiently satisfactory.

The classic indicator of reliability of the survey scale is alpha Kronbach. Reliability is the consistency of the results within a single test. Alpha Kronbach points to the degree to which all items actually measure the same property (quality). It should be noted that the high value of the coefficient indicates the existence of a general basis in the formulated set of questions. Professionally designed tests must have an internal consistency of at least 0.90. In our survey, the Cronbach coefficient α=0.96.

As can be seen from figures 2 and 3, informational and characteristic functions are acceptable for IRT analysis.

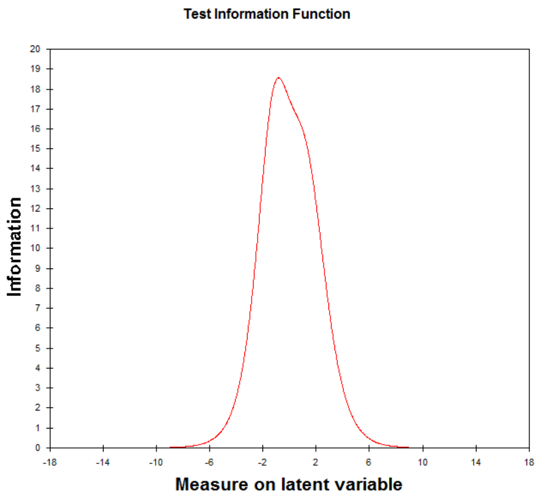

Figure 2: Information function.

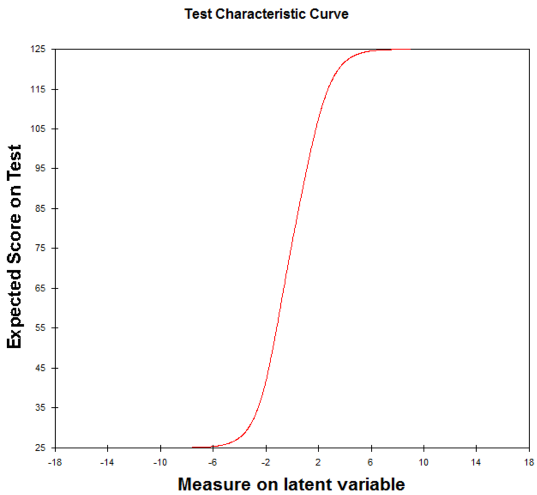

Figure 3: Characteristic function.

Person raw score-to-measure correlation = 1.00.

Cronbach Alpha (kr-20) person raw score "test" reliability = 0.96, sem = 4.07.

Item raw score-to-measure correlation = -1.00.

In columns INFIT and OUTFIT of tables 2 and 3 specified parameters that characterize the correspondence of the data to Rasch's model. In the field MNSQ (mean-square statistic) the statistics of the correspondence of the output data to the measuring model are showed, obtained on the base of the average sums of the squares of the deviations of the theoretical values from the empirical ones. The MNSQ values characterize the degree of "randomness" of the results or the discrepancy of the data to the used measurement model. Expected MNSQ values are near 1. The high MNSQ OUTFIT values can be associated with the "casual" respondents' responses. The high values of MNSQ INTFIT are usually interpreted as an indicator of the low validity of the tool, that is, the low suitability of the tool for the tasks for which it was developed. The most qualitative and significant (productive) measurements are those for which the MNSQ values lie in the range of 0.5 to 1.5. Higher values ($>$ 1.5) indicate uncertainty and "noise" in input data. Too low values ($<$0.5) are also not very desirable because they indicate excessive, "information overload" of the instrument. In the ZSTD field, the standardized MNSQ values are showed (with an average of 0 and a standard deviation of 1). Valid value is $-2.0 \leq$ ZSTD $\leq +2.0$.

For this survey, the match statistics for the measurements of all items are in this range, so they can all be used for further analysis.

Figure 4 shows the distribution of respondents and their judgments on the same interval scale (efficiency of the designed and deployed cloud-based environment). The content and composition of the questions in the survey is satisfactory – this is evident from the second bar graph on Figure 4. However, respondents' answers to the questions posed are not balanced. This means that some respondents answered randomly or could not orient themselves with the choice of an adequate response.

By analyzing table 4 in terms of the distractors included in the poll, the following conclusions can be drawn. Distractors with the lowest estimate of the efficiency of the proposed medium (Measure = -1.08, Item = CC3) and with the highest estimate of the efficiency (Measure = 0.75, Item = CA6) are not presentational for this study, since, as noted above, on the responses had an impact the factor of randomness and the factor of reluctance of respondents to understand the content of the questions deeply. The rest of the distractors can be divided into three groups according to the degree of influence on the overall efficiency: 1) with a small degree of influence on the overall efficiency (Measure from -0.43 to -0.12, Items = CP1, CP3, CP2, CS5, CA3, CP4, CI5); 2) with a mediocre degree (Measure from -0.09 to 0.07, Items = CS2, CS4, CI1, CC1, CI3, CA4, CA1, CA5); 2) with a large degree of impact on overall efficiency (Measure from 0.13 to 0.41, Items = CA2, CC4, CI2, CC2, CI4, CA7, CS3, CS1). The analysis of these distrac-

Table 2: Output table "Summary Statistics" (summary of 56 measured person).

	Total Score	Count	Measure	Model S.E.	INFIT		OUTFIT	
					MNSQ	ZSTD	MNSQ	ZSTD
MEAN	72.1	25.0	-0.20	0.25	1.06	-0.13	1.07	-0.14
SEM	2.9	0	0.18	0.00	0.08	0.29	0.09	0.29
P.SD	21.5	0	1.30	0.03	0.62	2.27	0.65	2.14
S.SD	21.6	0	1.31	0.03	0.63	2.19	0.66	2.16

Table 3: Output table "Summary Statistics" (summary of 25 measured item).

	Total Score	Count	Measure	Model S.E.	INFIT		OUTFIT	
					MNSQ	ZSTD	MNSQ	ZSTD
MEAN	161.6	56.0	0.00	0.17	0.98	-1.13	1.07	-0.80
SEM	2.5	0	0.07	0.00	0.17	0.83	0.19	0.88
P.SD	12.2	0	0.34	0.00	0.84	4.08	0.95	4.32
S.SD	12.4	0	0.35	0.00	0.85	4.16	0.97	4.41

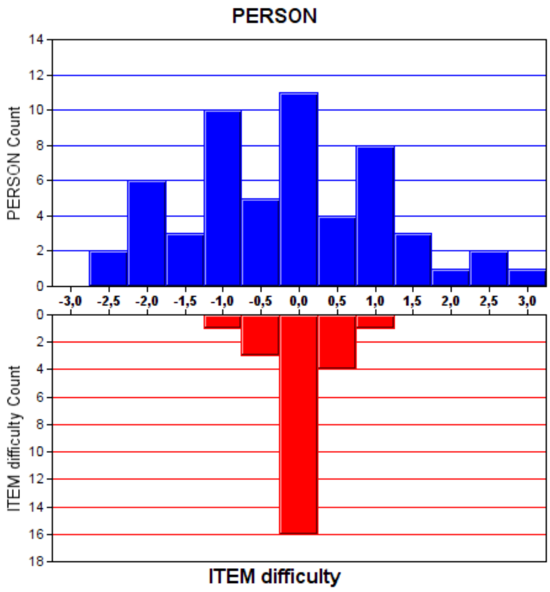

Figure 4: The relationship between the level of efficiency of the designed and deployed cloud-based virtual lab and the indicator variables.

tors at the content level will allow for the adjustment of the structure, some components in design of virtual cloud labs for the learning Cisco CyberSecurity Operations.

To further analyze the study data, we used the means of the R language in the RStudio environment. Currently, the MIRT package (Full-Information Item Factor Analysis (Multidimensional Item Response Theory)) is one of the most effective means of the R language to work with the Rasch model (Liu and Chalmers, 2018). This is open-source software, useful for real data analysis and research and provides a didactic tool for teaching IRT. It has no limits on the number of respondents or answers to questions. We used the mirt function to process and visualize the data. Here is the function call:

```
mod <- mirt(data = expdata,
      itemtype = "Rasch",model=1)
```

where

- expdata is a data frame with students' grades (link was provided above).
- itemtype is a type of items to be modeled. A value of 'Rasch' means that a credit model will be built by constraining slopes to 1 and freely estimating the variance parameters.
- model is a model to be built. A value of "1" means a unidimensional model.

To estimate the frequency of students' grades on all distractors, we constructed a histogram of response frequencies (figure 5). To do this, we used the P-function such as:

```
hist(d, breaks=c(0:5), freq=TRUE,
col= "blue",
xlab="Responses",
ylab="Frequency",
main="Frequency diagram")
```

The vector d is obtained from the full dataframe by extracting the header. That is, it contains columns of data without distractors.

Figure 5 shows that the answers at levels 4 and 5 were given the least. We can explain this by the fact that the proposed approach to the study of disciplines is innovative. Therefore, there is vigilance and caution of students to use it in the learning process.

To assess how clear the content of the distractors was for the respondents, we constructed a diagram using the next function.

```
plot(mod1, type = 'info',
xlim = c(-4, 4), ylim=c(0,40))
```

Table 4: Item statistics: measure order.

Entry number	Total Score	Total Count	Measure	Model S.E.	Item
11	135	56	0.75	0.17	CA6
1	147	56	0.41	0.17	CS1
3	149	56	0.35	0.17	CS3
12	151	56	0.29	0.17	CA7
16	151	56	0.29	0.17	CI4
19	154	56	0.21	0.17	CC2
14	155	56	0.18	0.17	CI2
21	156	56	0.15	0.17	CC4
7	157	56	0.13	0.17	CA2
10	159	56	0.07	0.17	CA5
6	160	56	0.04	0.17	CA1
9	160	56	0.04	0.17	CA4
15	160	56	0.04	0.17	CI3
18	160	56	0.04	0.17	CC1
13	161	56	0.02	0.17	CI1
4	162	56	-0.01	0.17	CS4
2	165	56	-0.09	0.17	CS2
17	166	56	-0.12	0.17	CI5
25	168	56	-0.18	0.17	CP4
8	169	56	-0.20	0.17	CA3
5	170	56	-0.23	0.17	CS5
23	172	56	-0.29	0.17	CP2
24	176	56	-0.40	0.17	CP3
22	177	56	-0.43	0.17	CP1
20	200	56	-1.08	0.17	CC3
Mean	161.60	56.00	0.00	0.17	
P.SD	12.20	0.00	0.34	0.00	

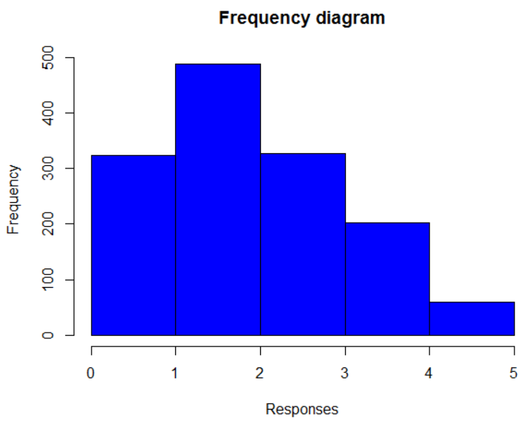

Figure 5: Histogram of response frequencies.

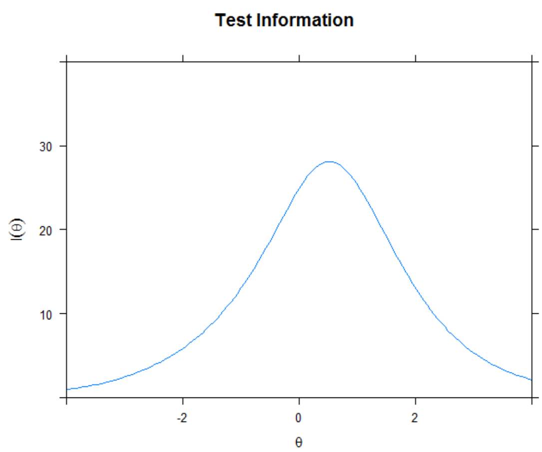

Figure 6: Graph of the information function of the questionnaire.

From the graph 6 of the information function we can conclude that the tasks of the polytomy type are the most informative for respondents with a level of training from -1 to 2 logs. This suggests that for students with an average level of preparation or slightly higher, the formulated questions were the most informative. The shape of the information curve (bell-shaped) indicates that the distractors were selected correctly and their description was made correctly.

The figure 7 shows the graphs of the characteristic functions of the responses to all distractors.

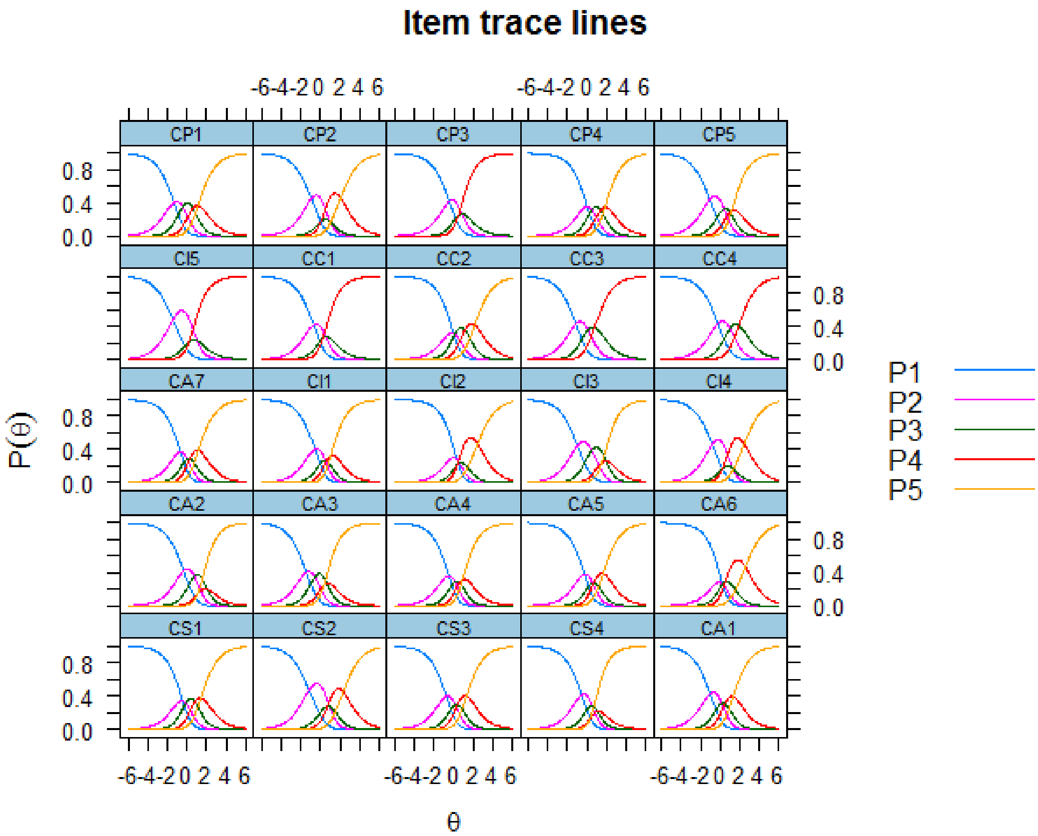

Figure 7: Characteristic curves of response levels.

As can be seen from these graphs, the probability of putting 1 point in students with a low level of preparation and the probability of putting 5 points in students with a high level of preparation was approximately 0.9. This is the case for all distractors. The probability of setting an average score by a student with an average level of preparation is low. But this is due to the higher frequency of averaging by most students.

4 CONCLUSIONS

The problem of integrating cloud-based tools and open online courses in the process of training future computer science teachers is relevant and needs further research. Cloud labs are one such form of integration. They ensure ubiquity and cooperation in learning. In particular, the authors deployed cloud labs to support training in Cisco CyberSecurity Operations and DevNet Associate Fundamentals Courses.

Learning the basics of cybersecurity is a topical issue of ICT students training. The course “CCNA Cyber Operations” of Cisco Network Academy provides an opportunity to organize such training. It contains a lot of theoretical materials, quiz tasks, discussion questions, labs, chapters exams and final exam. A virtual cloud laboratory was designed to carry out laboratory works at the course. For this purpose, the Apache CloudStack and EVE-NG Community Edition platforms were used. The virtual cloud laboratory provides the following possibilities: to create the required number of virtual machines; to change the computing power; to simulate the work of real computers and networks; to visualize different network topologies; to keep the state of virtual computers; to work remotely through a virtual private network; to combine separate virtual networks of students into a single network; to help students and control their learning outcomes.

DevNet Associate Fundamentals Courses is a very successful integrated course. It gives students the opportunity to put into practice theoretical lessons in networking and programming. It is also important to teach students to work with modern APIs. So future professionals will be able to create applications that process data obtained from the clouds. The course also demonstrates modern automation tools for the deployment of network and cloud infrastructures. The cloud lab also provides great learning opportunities in the DevNet course. In it, students can run VMs with basic development tools, run and test their application for a long time.

The conducted research and its statistical processing have limitations. They are associated with a small number of students have participated in the experiment. This sample size did not allow us to conduct a qualitative experiment to verify the statistical differences between the control and experimental groups. Nevertheless, statistical processing of the questionnaire “Course feedback” given by all students (even those who did not pass the final exam) indicates efficiency of the use of the deployed cloud laboratories. Along with high-quality training materials from the Cisco Network Academy, the students appreciated highly the functional and widespread access to the virtual objects of the cloud labs.

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Using the Virtual Chemical Laboratories in Teaching the Solution of Experimental Problems in Chemistry of 9th Grade Students While Studying the Topic "Solutions"

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Abstract: The article discusses the importance of student research activities for the effective formation of the key competencies of a future specialist in the field of chemistry, the importance of the skills of primary school students to solve experimental problems in chemistry and the conditions for the use of virtual chemical laboratories in the process of the formation of these skills. The concept of "experimental chemical problem" was analyzed. The essence of the concept of "virtual chemical laboratories" is considered and their main types, advantages and disadvantages that define the methodically reasonable limits of the use of these software products in the process of teaching chemistry, in particular, to support the educational chemical experiment are described. The main advantages and disadvantages of the virtual chemical laboratories on the modeling of chemical processes necessary for the creation of virtual experimental problems in chemistry are analyzed. The features of the virtual chemical laboratory VLab, the essence of its work and the creation of virtual laboratory work in it are described. It is determined that to support students' research activities, two types of virtual chemical laboratories are used: distance and imitation. The combination of these types of virtual chemical laboratories in the study of the topic "Solutions" provides an opportunity to take advantage of each of them and increase the level of support for learning research activities of students. Examples of developed virtual chemical works and their essence are given. Based on the implementation of virtual chemical laboratories in the educational process of various educational institutions, it is justified the assumption about the effectiveness of using the developed virtual experimental chemical problems to develop students' research activities when studying the topic "Solutions".

1 INTRODUCTION

Electronic learning tools are widely used in the educational process of teachers from different disciplines, but it is in the chemistry lessons of their use that is perhaps the most appropriate. A chemist should not so much accumulate knowledge as discover something new. Electronic learning tools, in particular virtual chemical laboratories, can bring the process of knowledge of chemical laws to a qualitatively new level: to facilitate the involvement of all participants in the educational process in active search and research activities, self-expression; to ensure the formation of critical and associative thinking, imagination; promote the development of the ability to argue, analyze data, justify and argue the conclusions.

One of the important means of developing chemical thinking and checking the strength of learning is the experimental problems in chemistry. However, now this kind of problems is practically not used in the educational process at school, but it is used at high levels olympiads in chemistry. One of the reasons for this phenomenon is the lack of time for the organization of experimental problems, the risk associated with possible harm to the health of students, the insufficient provision of schools with chemical reagents and equipment, and the like. Virtually all of the above problems can be solved with the help of appropriate means and tools of information and communication

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technology (ICT).

That is why the purpose of our work is to determine the capabilities of the virtual chemical laboratories to ensure the possibility of solving experimental problems in chemistry and developing the appropriate set of virtual computer problems.

To achieve this goal it is necessary to solve the following tasks:

- to analyze the concept of “experimental problem in chemistry” and find out the meaning and place of experimental problems in the school chemistry course;
- analyze the opportunity of using virtual chemical laboratories in pre-profile training;
- to find out the advantages and disadvantages of using different types of virtual chemical laboratories in the creation and implementation of virtual chemistry problems;
- apply the results of research in practice in the form of creating a set of virtual experimental chemistry problems for students in grade 9;
- to analyze the results of the virtual chemical laboratories introduction in the process of studying chemistry (topics “Solutions” in 9 grades).

2 THEORETICAL FOUNDATIONS OF USING VIRTUAL CHEMICAL LABORATORIES IN TEACHING THE SOLUTION OF EXPERIMENTAL PROBLEMS IN CHEMISTRY AND DEVELOPMENT OF STUDENTS’ LEARNING RESEARCH SKILLS WHILE STUDYING THE TOPIC “SOLUTIONS”

2.1 Experimental Problems as a Means of Teaching Chemistry

Chemistry is an experimental science, and that is why a chemical experiment in student’s develops a chemical style of thinking – the ability to understand the essence of chemical processes, their significance and how to manage them. The modern pedagogical process should be aimed at the child’s mastering the very techniques, methods, ways of thinking, that is, the student must master the technology of carrying out appropriate mental actions.

From the studies of famous teachers, didactists, psychologists, the formation of learning abilities is a complex process, the essence of which is to create opportunities for performing work related to learning. In particular, the competence-based approach (Modlo et al., 2018) focuses on the acquisition of skills, experience, and practical application of acquired knowledge in chemistry. Therefore, despite the fact that the content of educational material in chemistry is directed to students mastering practical skills in working with substances, provides for observation and experiment, solving computational and experimental problems, establishing causal relationships, the use of algorithms helps students in solving a number of problems, over time, develop into the ability to solve life problems (Savchyn, 2015).

Thanks to the educational chemical experiment, students acquire practical experience in obtaining facts and their preliminary synthesis at the level of empirical concepts, concepts and laws. Under such conditions, the chemical experiment performs the function of the method of educational cognition, thanks to which new connections and relationships are formed in the consciousness of the student, personal knowledge is formed. It is because of the educational chemical experiment that the activity approach to teaching chemistry is effectively implemented. But it is impossible to carry out an experiment without first considering the result and not drawing up an action plan. That is why the experimental problem solving as a kind of simulator are offered to students.

The solution of chemical problems is an important aspect of mastering the knowledge of the basics of chemical science. The inclusion of tasks in the educational process allows the following didactic teaching principles to be implemented: 1) ensuring the independence and activity of students; 2) the achievement of the strength of knowledge and skills; 3) implementation of the connection of learning with life; 4) the implementation of polytechnic chemistry training, vocational guidance (Zarubko, 2015).

The ability to solve problems develops in the process of learning, and this skill can be developed only in one way – to solve problem constantly and systematically.

Algorithmic actions of students in solving chemical problems in most cases is not at all in strict adherence to a specific procedure, guaranteed to lead to the correct result. But the learning algorithm, according to Savchyn (Savchyn, 2015), first of all means a certain variability of actions in search of the optimal way to solve the problem. In many cases, this variation in the course of isolation is inherent in experimental chemical problems.

Among the arsenal of chemistry teaching methods occupies a special place by the solution of experimental problems in the classroom and the execution of home experiments by students. Experimental problems are problems whose solution is accompanied by experiments. Pak (Pak, 2015) considers experimental chemical problems as a type of cognitive problems in chemistry. In contrast to laboratory work, students solve experimental problems on their own without additional instructions from the teacher. All students' work in solving experimental problems is built on an attempt to apply acquired theoretical knowledge and practical skills to solve a specific problem in conditions are close to real. In its content, the experimental problems can be directed to:

- observation and explanation of phenomena;
- preparation of solutions;
- execution of characteristic and qualitative reactions;
- recognition of substances.

You can also give another classification of experimental problems, according to which they are based on the activities of (Brajko and Mushkalo, 1982):

- familiarization with the properties of substances;
- determining the qualitative composition of substances;
- separation of mixtures;
- phased conversion of substances;
- determination of the quantitative composition of substances, mixtures;
- release of substances from the mixture in its pure form;
- quantitative problems on the laws of conservation of mass of substances and the stability of their composition;
- preparation of solutions of a given concentration and determination of the concentration of an unknown solution.

To solve any experimental problem, a certain sequence of actions is characteristic (Grygorovych, 2016):

1) drawing up an experiment plan (action algorithm), within which it is necessary to determine which specific question should be answered and which experiments should be carried out for this purpose;
2) the implementation of the experimental part;
3) the formulation of conclusions about the possibility of using the obtained experimental data to answer the question posed, and reasonable evidence or refutation of the initial assumptions.

Experimental problems in chemistry can be solved by the following methods: analytical-synthetic, hypotheses, and attempts. But mainly experimental problems in chemistry are solved by the analytical-synthetic method.

The use of experimental problems in the educational process allows us to solve a number of important pedagogical problems, in particular, to develop students' creative abilities and the ability to analyze the condition of the problem and select an experimental model, improve the skills of applying the laws of chemistry, and the like (Brajko and Mushkalo, 1982).

The choice of problem solving method depends on the students having theoretical knowledge and practical skills.

Students should be taught to choose a rational way of solving experimental problems. At the same time, students form the ability to analyze problems, make plans for decisions and reports.

In the class of studying new educational material, experimental problems can be used in various aspects: at the beginning of a lesson, to nominate a problem and arouse students' cognitive activity; during the lesson – in the study of the chemical properties of substances or substances; at the end of the lesson - to consolidate new knowledge.

In the lesson of consolidation of knowledge and the formation of practical skills, experimental problems can be used at its different stages in order to teach students to apply their knowledge to solve practical problems, or to study the device and the principle of the device and acquire the ability to use it.

In the lessons of generalization and deepening of knowledge, solutions to experimental problems are organized to specify the content of physical concepts and to establish new methods for measuring physical quantities and establishing new information about the phenomenon studied.

In knowledge control lessons, solving experimental problems will help test students' ability to apply knowledge in familiar and unfamiliar situations, analyze facts and take a critical look at the results of a chemical experiment.

At the lessons of control and accounting of students' knowledge, as well as at the lessons of generalization and deepening of knowledge, a significant part of the lesson and even the entire lesson can be devoted to solving experimental problems. It is advisable to solve complex problems, in particular the combined ones, which require knowledge of various sections of chemistry.

The ability to solve problems is one of the main indicators of the level of students' mastery of knowledge in chemistry. However, students often cannot solve a difficult task, although they discover the knowledge of theoretical material, they know the definition, the basic formulas, the laws, and solve standard problems. The reason is that students are used to solving typical tasks, and problems of an unknown type cause them to be confused (Mukan, 2002). The tasks are useful, as a result of which students get new information or acquire skills, tasks that make you think logically, based on theoretical knowledge, but with a creative approach. These criteria are exactly the experimental problems.

Selecting experimental problems, it is necessary to take into account the age of students, their psychological characteristics and the level of knowledge in chemistry. Experimental problems are highly effective when students have sufficient knowledge of the relevant material. The form of the problem statement should be convenient for solving at each stage of the lesson.

Today there are many manuals and periodicals in which you can find a selection of experimental problems on a particular topic and are ready to solve them. However, the current trend is the introduction of information technology training in the process of formation of the subject competence of students. It can be said with confidence that students' performance of experimental problems using information and communication technology tools will be more interesting for students and more productive (Brajko and Mushkalo, 1982).

2.2 Development of Students' Learning Research Skills While Studying the Topic "Solutions"

The educational institution must prepare a student who thinks creatively, has theoretical and fundamental knowledge, appropriate skills for the independent work and the ability to process and explain the results of their research.

One of the most important competencies that students acquire in the learning process is research competence – it is the formed quality of personality, which is ex-pressed in the mastery of knowledge, skills and methods for the effective research and the ability of independently acquire new knowledge (Mindeyeva, 2010; Nechypurenko et al., 2016; Leshchenko et al., 2021).

The formation of students' research competence takes place in the process of independent creative research activity and is a necessary condition for the professional development and self-improvement of the individual. Learning research activity is practically the only means for the formation and development of research competencies.

Modern specialized education should initiate and develop the individual's ability to carry out research activities, higher education institutions – to consolidate and deep these skills, as well as bring them to the highest level – the ability to conduct independent research.

Thus, research skills should be formed in school, which takes place in the form of the learning research activities. This is done by involving students to the implementation of the educational research, projects, introduction to the educational process the elements of research activities.

Independent acquisition of new knowledge about the environment is the purpose of learning research activities, in contrast to the usual educational activities (explanatory and illustrative).

We are most impressed by the opinion of Nefedova (Nefedova, 2012), who interprets the research activities of students' as "the process of solving a creative problem that does not have the result, based on mastering the features of the environment through the scientific methods, during which the translation of cultural values".

Therefore, the research is characterized by an active cognitive position which is based on the internal search for answers to any question, through comprehension and creative processing of data, action through "trial and error", the activation of critical thinking.

The work on the formation of research skills in chemistry lessons can be divided into four interrelated areas (Zabolotnyi, 2007):

1) inclusion of research elements in the structure of the lesson while studying new material;
2) organization of laboratory and practical work as research, which will provide an opportunity to increase the level of interest of students in obtaining and interpreting the results of these works;
3) formulation of homework in the form of research can diversify this form of work and make it more interesting;
4) planning and conducting extracurricular activities (research group, project work), using problems with active research activities.

The current state of the most schools in Ukraine does not allow students to carry out research activities on a large scale – covering the whole classes, and is implemented, as a rule, only with children in the category of "gifted" and, mainly, in the form of extracurricular activities.

Solutions is the most common objects of students' research in chemistry. Because the solutions surround a person in nature, everyday life, industry and other areas of activity, students get acquainted with them in childhood. In the course "Natural Science" (5th grade) this acquaintance is more substantive and scientific. Solutions be-come the main object of study and research in the 9th grade during the study of the relevant topic in the course of chemistry (Velychko et al., 2017).

The chemistry curriculum in 9th grade (Velychko et al., 2017) provides for solving experimental problems at this topic, as well as the equations of reactions using solutions with a certain mass fraction of solute; using of demonstration experiments, laboratory experiments, practical work, preparation and defense of educational projects.

Most of these forms of work directly or indirectly contribute to the development and improvement of learning research skills of students. However, it should be noted that a number of planned laboratory experiments and practical work will be performed in an abbreviated or demonstration form. If we talk about the development of research skills of students, then there is a need for additional chemical experiments, which aim to reveal the essence of the phenomena studied, to provide students with a creative approach to solving research problems, to consolidate theoretical knowledge through multiple empirical confirmation.

The most important and most complex semantic parts of this topic are the solubility of substances, its dependence on various factors; saturated and unsaturated, concentrated and diluted solutions; thermal phenomena accompanying the dissolution of substances; the concept of crystal hydrates; electrolytic dissociation. Therefore, the learning research activities should be directed to the study of these semantic parts of the topic.

The topic "Solutions" is the central in the study of chemistry, because it is inter-twined with important sections of inorganic and organic chemistry, chemical technology; the processes of dissociation, ion exchange reactions and other types of reactions are also somehow related to this topic.

The prevalence and availability of solutions also makes them as the unique object for students' learning research activities. A significant number of classes at this topic can be organized in the form of educational research, both laboratory and home (applied).

While studying the topic "Solutions", students acquire skills in working with chemicals, chemical equipment (including measuring equipment), the ability to observe, measure, calculate. At the same time, learning research activities provide an opportunity to do this at a better level, while developing the ability to make assumptions, build algorithms for testing them, conduct experiments and formulate conclusions.

The problems of effective organization of the learning research activities of students while studying the topic "Solutions" are:

- insufficient time to conduct a large number of different learning experiments (especially long-term);
- imperfections in the material support of school chemical laboratories (lack of scientific equipment, potentially dangerous substances and precursors, insufficient number of utensils, etc.);
- limitations related to the physical abilities and health of individual students, features of psychical and mental development, cognitive activity, etc.

2.3 Virtual Chemical Laboratories as a Tools of Teaching Chemistry

When studying chemistry at school, one of the most difficult tasks facing the teacher is to familiarize students with real chemical objects and processes. This difficulty is due to the simplicity and lack of equipment in school chemical laboratories, restrictions on the use of certain chemical compounds in them, reduction of time to study certain topics in curricula, and the like.

A solution to these problems is to use information and communication technologies in the educational process, in particular spreadsheets (Semerikov et al., 2018), augmented reality tools (Nechypurenko et al., 2018; Kharchenko et al., 2021; Midak et al., 2021) and virtual chemical laboratories (VCL) (Nechypurenko et al., 2019; Lytvynova and Medvedieva, 2020).

According to Trukhin (Trukhin, 2002), a virtual laboratory "is a hardware-software complex that allows experiments to be carried out without direct contact with a real installation or in the complete absence of it. In the first case, we are dealing with a so-called laboratory setup with remote access, which includes a real laboratory, software and hardware to control the installation and digitization of the data, as well as means of communication. In the second case, all processes are modeled using a computer".

So, under the virtual laboratories understand two types of software and hardware systems (Trukhin, 2002):

- laboratory installation with remote access (remote laboratories);
- software that allows to simulate laboratory experiments – virtual laboratories (in the narrow sense).

Thus, we can distinguish two types of virtual laboratories: remote and simulation.

Remote virtual chemical labs provide remote access to real lab equipment either in real time or by playing relevant videos. The remote virtual laboratory includes:

1) a real laboratory with real equipment and reagents;
2) software and hardware for control of the corresponding equipment and digitization of the received data;
3) tools of communication to connect users with the first two components.

Virtual laboratories, in which the relevant equipment, substances and processes are modeled using a computer or other gadgets, are a set of programs designed to simulate laboratory work in the laboratory (Trukhin, 2002). Simulation virtual chemical laboratories can be represented by a set of immutable models, as well as mathematical interactive models that can adequately reflect the effects of various user actions associated with changes in the conditions of the experiment, in its results. The main advantage of such virtual chemical laboratories is the ability to implement a creative approach to the implementation of virtual experiments by users and the formation of users a more holistic view of the simulated processes and phenomena.

Both types of VCL have common advantages:

- no need to purchase expensive equipment and reagents. Due to inadequate funding, many school chemical laboratories have old equipment installed that can distort the results of experiments and serve as a potential source of danger for students. Also, in addition to equipment, consumables and reagents are required, the cost of which is quite high. It is clear that computer equipment and software are also expensive, but the universality of computer equipment and its wide distribution and availability somewhat compensate for this disadvantage.
- the possibility of modeling processes, progress or observations of which are fundamentally impossible in the laboratory. Modern computer technologies by means of visualization on the monitor screen provide an opportunity to observe processes that cannot be observed in real conditions without the use of additional equipment, for example, due to the small size of the observed particles or difficult to achieve conditions (ultra high or ultra low temperatures, pressure, etc.).
- the possibility of penetrating into the subtleties of processes and observing the details of a phenomenon that occurs on a different time scale, which is important for processes occurring in a fraction of a second or, on the contrary, last for several years.
- no immediate danger to the lives and health of students. Safety is an important advantage of using VCL, especially in cases where the work involves, for example, the use of hazardous chemicals or devices associated with the use of high temperatures, pressures, electric current, etc.
- saving time and resources for transferring the results into electronic format.
- the possibility of using VCL for informal education and distance learning, is to ensure the possibility of performing laboratory work in chemistry for the lack of access to school laboratories, including when working with children with limited physical abilities who miss classes due to illness or under quarantine time.
- the development of skills to find the optimal solution, the ability to transfer the real problem in model conditions and vice versa.

Perhaps the disadvantage of using virtual chemical laboratories is that the model objects created by the computer are completely supplanted by the objects of the child in the real world. But working with sign systems is the basis of analytic-synthetic activity, that is, thinking does not exist outside of abstraction and symbolization. Also, significant shortcomings of the VCL are the limited information that they transmit to various users' senses, and the inability of students to develop skills in working with real laboratory objects.

By the way of visualization, laboratories are distinguished using two- and three-dimensional graphics and animation.

Also, virtual laboratories are divided according to the way they represent knowledge of the subject area. In one case, virtual laboratories are based on individual facts, limited to a set of pre-programmed experiments. They represent a specific set of laboratory studies, compiled in accordance with the curriculum. Experiments in such virtual laboratories can only be viewed. Intervention in their course is impossible (Derkach, 2008).

Otherwise, conducting virtual laboratory experiments is based on a mathematical model of a real chemical process. Such virtual laboratories provide for the possibility of changing the experimental conditions within certain limits and adequately reflecting these changes in its results. Licensed versions of such programs, as a rule, provide an opportunity to create your own laboratory work. Such virtual laboratories contribute to independent knowledge of the world by students and provide an opportunity for the teacher to realize their creative abilities regarding the chemistry learning process.

The development of VCL, based on mathematical modeling of real chemical processes, is more complex and time-consuming, but significantly expands the possibilities of their application (Derkach, 2008).

Examples of such VCL are Yenka Chemistry (Yenka, 2017), Model ChemLab (Model Science, 2019) and Virtual Lab (VLab) (ChemCollective, 2018). The only virtual chemical laboratory that meets these requirements and is freely available is the Virtual Lab, so we decided to implement the development of a set of experimental problems in it.

Any of the VCL is only a model of the real world, and therefore, like any other model, there is a certain limitation, simplicity. Different virtual chemical laboratories have a different level of simplicity compared to real chemical laboratories: different in detail graphic display of objects, lack of transmission of smells and tactile sensations of objects manipulated in a virtual environment (Nechypurenko, 2012).

ChemCollective Virtual Lab software currently covers more than 50 exercises and problems that help in mastering chemical concepts, mainly related to the study of solutions and the processes that take place in them (Chemcollective.org, 2018b).

On the other hand, the use of remote virtual laboratories provides an opportunity to observe high-quality visualization of relevant processes occurring with real objects – it is possible to conduct high-quality chemical experiments and perform practical work or experimental problems of a qualitative nature. However, this type of virtual laboratories, at least those that are publicly available, do not provide the opportunity to interfere in the process and perform quantitative experiments.

Remote virtual laboratories should be used in the same types of lessons as other virtual chemical laboratories: at the stage of learning or consolidating new material, as independent or home research, in classes of relevant electives or groups, and to test students' knowledge (in the form of experimental problems).

Simulation virtual laboratories have the advantage over remote ones in the ability to change the experimental conditions many times and perform all the experimental operations almost instantly (saving time), the advantage of remote virtual laboratories is a more realistic reproduction of all details of the experiment.

Thus, in our opinion, it is possible to qualitatively support the learning research activities of chemistry students in the study of the topic "Solutions" by combining the capabilities of two types of virtual chemical laboratories – remote (for qualitative experiments) and simulation (for quantitative experiments).

In both cases, there is a need to develop their own laboratory works, which will be implemented through virtual chemical laboratories and will be adapted to the content of the curriculum for secondary schools in chemistry (topic "Solutions", grade 9).

3 METHODICAL BASIS FOR THE DEVELOPMENT OF A SET OF EXPERIMENTAL PROBLEMS IN CHEMISTRY FOR STUDENTS IN GRADE 9 IN THE CLOUD-ORIENTED VIRTUAL CHEMICAL LABORATORY VLAB

3.1 Features of the Virtual Chemical Laboratory VLab

The most accessible of the modern VCL, providing the ability of the user to intervene in the course of a virtual experiment, as well as the possibility of developing their own virtual laboratory work is the Virtual Lab (VLab).

The goal of the VLab virtual chemistry lab, which is a ChemCollective product, is to create flexible, interactive learning environments in which students can approach chemistry as practicing scientists.

ChemCollective began with work on the IrYdium Project's Virtual Lab in 2000. The project was to create training exercises designed to provide interactive, interesting materials that link chemical concepts with the real world.

The project leader is Dr. David Yaron, Professor of Chemistry at Mellon College of Science. Most of the original exercises included in this virtual lab were developed by a team at Carnegie Mellon University, including Yaron, experienced software engineers, student programmers, educational consultants, and editors (Chemcollective.org, 2018a).

Virtual chemical laboratory Virtual Lab is free to install, use and distribute. It can be used both online (by running the virtual lab plugin from the Chem-

Collective website using any browser) or locally by downloading the installation files and installing the program on the computer.

Virtual Lab can also be integrated with the Moodle system using a special plugin. This makes it possible to apply the individual tasks of the virtual lab directly to the specific topics of the Moodle course (Nechypurenko and Semerikov, 2017).

In each assignment of the virtual chemical laboratory VLab, access to chemical reagents, which may include general purpose reagents or compounds specific for a given job, as well as chemical glassware (beakers, conical flasks, graduated cylinders, pipettes, volumetric flasks of various volumes, also a 50 ml burette and plastic cup) and equipment (Bunsen burner, weighing hook and scales).

A separate panel of the program window is designed to provide information about a substance or a mixture: name, volume, state of aggregation, amount of substance (mol or g), concentration (mol/l or g/l), spectrometer data, pH meter, and thermometer. Some of these tools can be disabled if this is required by the condition of the problem, which is solved in this virtual laboratory (figure 1).

All actions with dishes and substances in it are performed in drag and drop mode, that is, by simply dragging objects with the left mouse button. The same operations, as well as some specific actions, can be carried out through the menu that appears when you click on an object with the right mouse button(Yaron et al., 2010).

The essence of the program is to download certain problems and solve them experimentally or calculated with the subsequent experimental verification of the result. There are no restrictions on the number of attempts to perform experience on restrictions on the use of certain quantities of reagents and materials.

Using the exercises of the virtual laboratory VLab, according to its developers, provide the ability to:

- help students who have missed class work in the laboratory to do an experiment from their personal computer, without the need to do work under the supervision of a teacher;
- supplement current work and homework on paper with exercises that allow students to use chemical concepts to design and perform their own experiments;
- monitor the correctness of the assignments of students (students use a virtual laboratory to check the results of their own calculations or qualitative forecasting without risk to their own health);
- to supplement the demonstration experiment conducted in the classroom (teachers first carry out a demonstration in the classroom so that students can see the actual chemical processes, and the students then study the chemical system and processes independently, guided by the problems in the virtual laboratory).

Virtual Lab software currently includes more than 50 exercises and problems that are designed to assimilate chemical concepts, mainly related to the study of solutions and processes in them: moths, stoichiometry and limiting reagents (problems for excess), density, dilutions, dissociation constant, acids and bases, thermochemistry, solubility, chemical equilibrium, redox processes (Chemcollective.org, 2018b).

The installation package of Virtual Lab contains thirteen launch files for this program in different languages, among which Ukrainian since 2014 has been. Running the local version of the program, as well as the old online version, required the presence of a Java plug-in. Recently, this plugin has been blocked by most browsers and antivirus programs, it requires separate settings on the system, therefore, in 2017, the HTML5 version of the VLab was launched on the ChemCollective website in 2017, which currently supports only three languages: English, Spanish and Italian.

On the old version of the ChemCollective site (http://collective.chem.cmu.edu), you can download a special problem editor, the Virtual Lab Authoring Tool, which allows you to both modify existing problems and develop your own from scratch for the local version of the program.

In the problem set, included in the standard version of the VLab program, most of the virtual works are oriented to a level higher than the level of the basic school – core, or college and university. The content of a certain number of problems is structured in such a way that all of them are full-fledged study and research problems (Nechypurenko and Semerikov, 2017). Our work was thus aimed at developing problems that can be classified as experimental chemical problems on the “Solutions” topic, were coordinated with the curriculum, and at the same time were available for primary school students in terms of complexity.

3.2 Creation of Laboratory Work in a Virtual Laboratory VLab

In order to create your own laboratory work, you need to understand how this virtual lab works. The virtual laboratory is launched by running the default.xml file (or default_uk.xml for the Ukrainian version), which is located in the assignments directory. This is the default virtual lab file. This file contains individ-

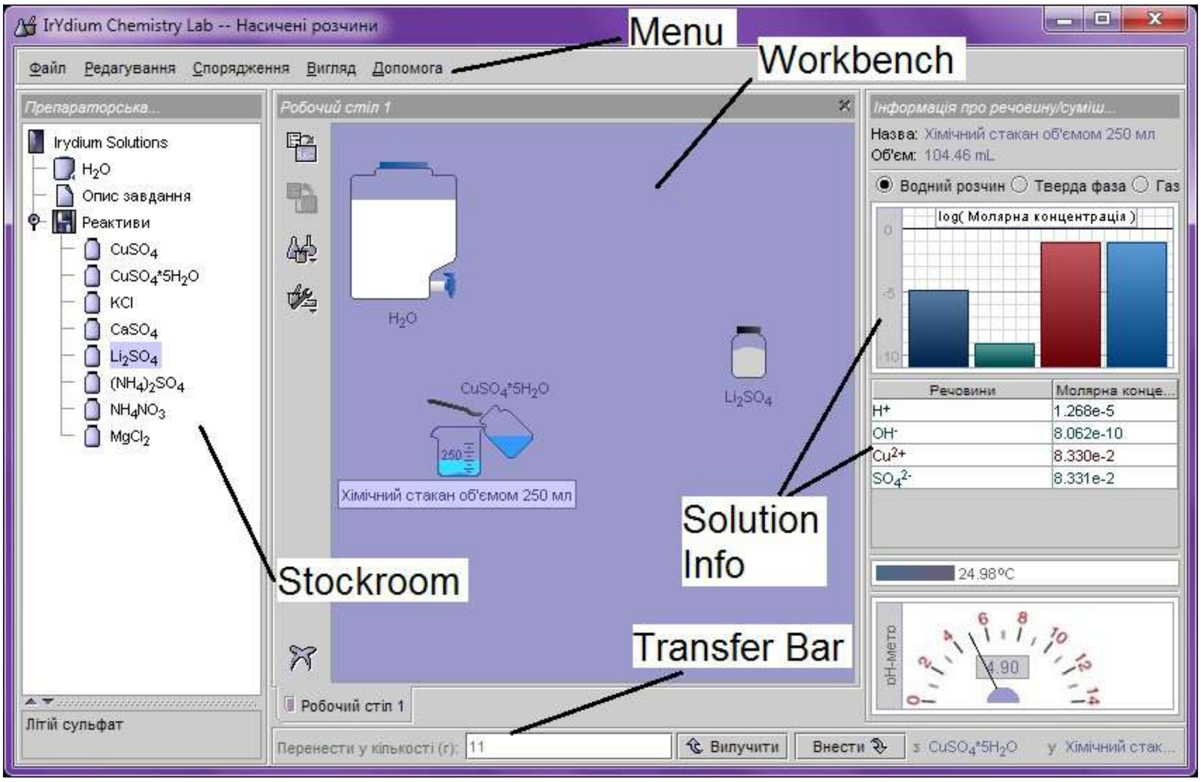

Figure 1: VLab window with virtual laboratory work.

ual properties of the program's working area: the availability of tools (thermometer, pH meter, windows with information about the chemical composition of substances and solutions) and the available modes of substance transfer (accurate transfer, transfer of rounded quantities and realistic transfer). These tools and transfer modes can be either available for work, all or some of them can be turned off depending on the needs of the problem scenario. Also in this file are the ways in which the working area of the program is filled with reagents, possible physicochemical processes with their participation, a description of the work problem, and the like. These default paths lead to files that are in a subdirectory with the same name as the control xml file — that is, the files to work with, are guided by the default_uk.xml file, are in the default_uk directory (the path to it is in the program directory assignments/default_uk). The directory referenced by the control xml file contains typically four files:

- filesystem.xml – contains information about the solutions (reagents) planned for use in this virtual laboratory work and the dishes in which they are contained, their volume or mass, and a brief description of this reagent (name, concentration, etc.);
- reactions.xml – contains information on all possible (planned) chemical reactions with a specific set of substances in this virtual laboratory work;
- species.xml – contains information on all substances available in this virtual laboratory work and their properties (color, state of aggregation, thermodynamic parameters, molar mass, etc.);
- problem_description.html – contains a text description of the problem and instructions for performing virtual lab work.

VLab versions higher than 2.1.0 may also contain the spectra.xml file, which contains the spectral characteristics of the substances that will be displayed in the photocolorimeters window, if it is available for use in this work.

Other laboratory works are started on the same principle, only the control xml-files are located in separate thematic sub-subdirectories in the subdirectories of language localization, for example, the control xml-file of the localized Ukrainian work "Determining the solubility of CuCl2 at different temperatures" CuClSolu.xml is located along the path assignments/problems_uk/solubility.

The list of control xml files with the path to them and a brief description of the work is in the ProblemIndex_uk.xml file (ProblemIndex.xml for the standard English version) in the root directory of the program. From this file that the list of laboratory works available for execution is called up via the menu "File" → "Load problem".

Any of these files can be edited using Notepad (it is important to save changes in the UTF-8 encoding) or any xml file editor. But a more optimal option is to use the special editor Virtual Lab Authoring Tool. There are several options for creating a new laboratory work: from scratch, editing and saving the default xml file, and based on another work. The second way is faster and more rational, since it allows partially (and in some cases, possibly completely) using those reagents, equipment and other necessary parameters of work, since they have already been entered and are guaranteed to work. To make this change, open the control xml file in the Virtual Lab Authoring Tool editor and select "Save As ..." in the "File" menu, specify the new file name and its location. In our case, it was the School catalog, which we created specifically for this set of works. A directory with content files is automatically generated.

Henceforth control xml-file in the editor Virtual Lab Authoring Tool need to edit. The editor window has several tabs, each of which changes a certain part of the work data (figure 2):

- General – contains fields for entering the title of the work, the last name of the author and a brief description of the content of the work.
- Permissions – contains two tabs: Viewers to specify the tools for viewing the properties of substances and their chemical composition will be available during the work; and Transfer Bars to determine the substance transfer parameters available in the job.
- Species – contains tools for creating and editing substances needed in this work. In addition to the formula, the molar mass and the name of the substance, the state of aggregation, as well as its coloring parameters, its standard enthalpy of formation and entropy are obligatory characteristics – these data will be used to simulate chemical reactions between the corresponding substances.
- Reactions – contains tools for planning the flow of physicochemical processes, by defining reactive particles as reagents or reaction products, setting appropriate coefficients.
- Stockroom – provides the ability to create and edit the contents of the "Stockroom" in the virtual laboratory – add cabinets, dishes with reagents, accompanying files (description of the problem, etc.).

At the end of the work in the editor Virtual Lab Authoring Tool you need to save the changes and make the created work in the registry of works so that it becomes available for use. To do this operation, a block is created in the ProblemIndex_uk.xml file (editing with a notepad or xml editor):

```
<DIRECTORY name="The name of the block
   of laboratory works">
  <PROBLEM url="assignments/problems_uk/
 school/File_name.xml">
    <TITLE>Problem title</TITLE>
  <AUTHOR>Autors</AUTHOR>
  <DESCRIPTION>
    A brief description of the problem
  </DESCRIPTION>
 </PROBLEM>
</DIRECTORY>
```

A block limited by <DIRECTORY> ... </DIRECTORY> tags can contain as many individual works as desired, each of which is separated by <PROBLEM> ... </PROBLEM> tags.

Created or edited works become available after the next program launch.

3.3 A Set of Experimental Chemical Problems in a Virtual Chemistry Lab VLab for Use in School When Studying the Topic "Solutions"

The chemistry curriculum in grade 9 (Velychko et al., 2017) provides for the solution of experimental problems on this topic, as well the computational problems using solutions with a certain mass fraction of solute; use of demonstration experiments (thermal phenomena during dissolution: dissolution of ammonium nitrate and concentrated sulfuric acid in water, studies of substances and their aqueous solutions for electrical conductivity, exchange reactions between electrolytes in aqueous solutions) conducting laboratory studies (detection of hydrogen and hydroxide ions in solutions, established approximate pH values of water, alkaline and acidic solutions (sodium hydroxide, hydrochloric acid) using a universal indicator, pH studies search and cosmetic products, the exchange reaction between electrolytes in aqueous solutions, accompanied by precipitation, the exchange reaction between electrolytes in aqueous solutions, accompanied by the evolution of gas, the exchange reaction between electrolytes in aqueous solutions, followed by water absorption, the detection of chloride, sulfate and carbonate ions in solution) carrying out practical work (ion exchange reactions between electrolytes in aqueous solutions) of executing a home experiment

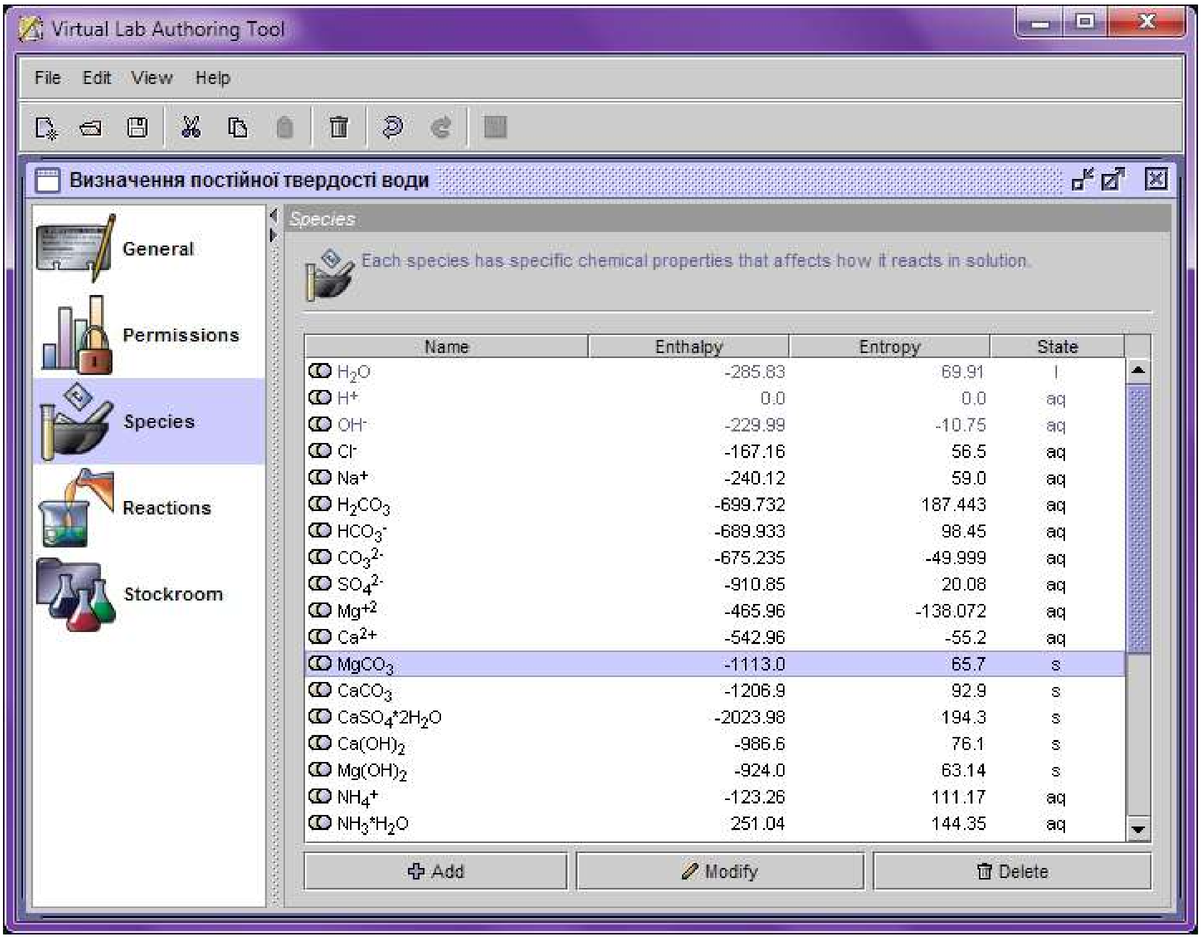

Figure 2: Editor Virtual Lab Authoring Tool window.

(preparing colloidal solutions (jelly etc.)), preparation and protection of educational projects ("Electrolytes in modern accumulators", "Growing of crystals of salts", "Production of solutions for provision of medical assistance", "Research of soil pH of the area", "Investigation of the influence of acidity and alkalinity of soils on plant development", "Research pH of atmospheric precipitation and their influence on various materials in the environment","Investigation of natural objects as acid-basic indicators", "Investigation of the pH of the mineral water of Ukraine").

The most important and most complex parts of this topic are the solubility of substances, its dependence on various factors. Saturated and unsaturated, concentrated and diluted solutions. Thermal phenomena accompanying the dissolution of substances, dissolution as a physical and chemical process, the concept of hydrates, electrolytic dissociation etc. Therefore, experimental problems should be directed to the study of precisely these substantive parts of the topic.

After analyzing the technical and visual capabilities of the Virtual Lab, we determined that it would be most appropriate to create virtual experimental problems related to the dissolution process (its energy and quantitative characteristics), the dissociation process of substances in a solution and determine its pH, as well as the use of some qualitative reactions, indicators and the like. The problems associated with the study of the properties of colloidal solutions, the flow of certain exchange reactions, the extraction of crystals, the study of the analytical effects of qualitative reactions associated with the formation of precipitation cannot be realized either due to the limited possibilities of modeling chemical phenomena in the VLab and due to the limitations of visual accompaniment (for example, to conduct qualitative reactions with the formation of sediment among the equipment in the VLab there are not enough test tubes, and the presence of sediment and its color become noticeable in a glass x on the desktop of the virtual laboratory only in quantities of a few grams or more, does not comply with the principles of qualitative chemical analysis).

Based on all the above, we have created a trial set of experimental problems on the topic “Solutions”, which contains seven problems. The works contain instructions for solving problems and a number of questions that students need to answer.

For example, the laboratory work “Precursor” suggests that the student present himself as a laboratory technician and carry out dilutions of concentrated sulfuric acid, which is on the list of precursors. The task is to prepare equal volumes of solutions with the indicated concentrations.

In the work “Separation of salt mixture”, it is necessary to separate the mixture of crystalline potassium chlorate and sodium chloride by recrystallization of potassium chlorate, based on the difference in the solubility of these salts. The problem contains the order of actions that will help to perform the work. The purpose of this problem is to familiarize students with the methods of purification and separation of substances, the dependence of the dissolution of salts on temperature.

To demonstrate the preparation of saturated solutions, you can use the work “Preparation of saturated solutions of various chemical compounds”. Here the student will be able to prepare solutions by changing the temperature, and on the basis of the data obtained, construct curves for the concentration of a saturated solution of a substance on temperature. The aim of the work is to study the change in the solubility of substances from temperature, the formation of skills in the preparation of saturated solutions, the analysis of the experimental data.

The study of thermal effects of dissolution can be carried out in the work “Thermal effects of dissolution”. In the description, it is reported that during the dissolution of the substance various physical and chemical processes take place with both the solute and the solvent. One of the external indicators that can be easily fixed is the thermal effect observed when various substances are dissolved. The task is to investigate the thermal effects of dissolution of various crystalline compounds in water and to draw appropriate conclusions and assumptions regarding the processes leading to the occurrence of these effects. The purpose of the work is to form an understanding of the thermal phenomena that accompany the process of dissolution and test them in practice, consolidating knowledge about exo- and endothermic processes.

The overwhelmingly developed problems contain a sufficient number of hints so that the student can experiment in a virtual laboratory independently, for example, on a home computer, and some of the problems are quite realistic to reproduce in a real school chemistry laboratory, given the time and possibilities (in this case problem solving in a virtual laboratory can be used as a training option to verify the correctness of theoretical calculations and repeat the order necessary action).

A set of these laboratory works are posted on the website of the Department of chemistry and methods of learning chemistry at the Kryvyi Rih State Pedagogical University (https://kdpu.edu.ua/khimii-ta-metodyky-ii-navchannia/tsikava-khimiia/dlia-vseznaiok/5928-virtualna-khimichna-laboratoriia.html) with the aim of further introducing schools into the educational process and receiving feedback on improving the quality and expansion of this set.

4 CREATION AND TESTING OF A SET OF VIRTUAL LABORATORY WORKS FOR THE ORGANIZATION OF LEARNING RESEARCH ACTIVITIES OF STUDENTS IN CHEMISTRY IN THE STUDY OF THE TOPIC “SOLUTIONS”

Most of the problems in the set developed for the topic “Solutions” in VLab are formulated in a research (problem) style – the student has a task:

1) to obtain a certain practical result;
2) to study processes and phenomena, the exact properties of which are unknown to him in advance.

In the first case, the student has the opportunity to create their own algorithms and check their adequacy in practice, but in a virtual environment. The use of trial and error method is not ruled out. In the second case, completing the problem will mean for the student the discovery of subjectively new patterns, properties, and so on. That is why, the student has the opportunity to independently, based on the results obtained in the virtual chemical laboratory, to draw conclusions about the influence of the certain factors on the dissolution process, and only then compare them with those in textbooks described, heard from the teacher’s story, etc.

Most of the problems contain enough prompts for the student to experiment in a virtual laboratory on their own, for example, at a home computer, and some of the problems can be reproduced in a real educational chemical laboratory of the school if time and opportunity (in this case the problem in the virtual laboratory can be used as a training option to check the correctness of theoretical calculations and repeat the order of necessary actions).

The VLab virtual chemical laboratory provides the possibility of independent repeated experimentation with various substances and their solutions, with the involvement of accurate measuring instruments, but it is not designed to perform qualitative reactions. Most qualitative reactions do not require accurate calculations and measurements, but they do require as clear an analytical effect as possible, not distorted by the imperfection of the object's appearance in its model. For the virtualization of qualitative experiments, qualitative visualization is often more desirable than the ability to make accurate measurements. Since in the topic "Solutions" a certain amount of student research is related to qualitative chemical experiments (performing qualitative reactions, determining the acidity of the environment using indicators, etc.), there is a need to create a resource to support of qualitative chemical experiments. The most realistic transmission of visual information about an object is a video recording. The essence of the developed remote virtual chemical laboratory is to provide users with remote access to a set of substances that can be used to perform high-quality laboratory experiments. At the same time, we tried to anticipate various options for user actions, including those that could have been done accidentally, without logical justification. To do this, the program interface is organized in such a way that the user has two sets of reagents. Any reagent from the first set can be mixed with any reagent from the second. Selecting the appropriate pair of reagents triggers a short video recording of the mixing of these reagents in a real chemical laboratory. The user can not change the number of reagents or the order of their addition, but has the opportunity many times to observe high-quality visualization, accompanied by a textual description of the nature of the reaction that occurs.

The availability of such a virtual chemical laboratory can be ensured by placing it on the Internet on the pages of the site. The window interface of such a remote virtual chemical laboratory is essentially the html-page of the site. For the operation of a laboratory installation with remote access, it is necessary that the site page contains a set of elements of JavaScript, video, codes, etc. that relate to a separate laboratory work (figure 3).

The operation of the remote virtual chemical laboratory created by us is provided by a number of objects located in different directories:

- the *favicons* folder contains favicon elements, ie site icons for different browsers;

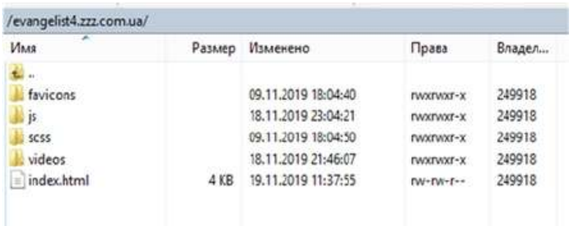

Figure 3: Elements of the site of the laboratory installation with remote access.

- *js* folder is a folder for saving java script files that provide dynamic interactivity on the site;
- *scss* folder contains style files that form the external design and stylization of the site page;
- all videos of the experiments that we recorded for running on the site are saved in the *videos* folder;
- the *index* file is the main one, because the main startup code of the laboratory is written in it.

The following online page of the virtual chemical laboratory involves the execution of certain program code, which can be edited by connecting to an FTP server and launching Notepad++ or xml-editor.

The general principle of the first virtual laboratory with remote access on the topic "Indicators" is to select buttons from the upper left corner – the indicator, and the lower left corner of the solution with a certain level of acidity, such a combination of pressing "show" allows you to run videos where the first reaction, change of color of solution is shown (figures 4 and 5).

To return to the indicator and solution selection, press the "Clear" button in the middle on the left and start the selection again.

The following laboratory work No 2, created on the basis of the site, is based on an experimental problem on "Qualitative reactions to the most common anions". The general principle of operation is similar to the virtual chemical laboratory "Indicators" and consists in selecting the buttons from the upper left corner – solutions of reagents $AgNO_3$, $Pb(NO_3)_2$, $BaCl_2$, and the lower left corner - a solution containing an unknown anion to be determined by students. When you press the "Show" button, a video is launched, which shows the course of the chemical reaction between the selected solutions.

It should be noted that both laboratory works can be used as research: the "Indicators" lab contains not only the indicators described in the textbook, but also non-standard for the school curriculum – bromocresol purple, congo red, red cabbage juice, and therefore work with them is easy to organize as a research. The work "Qualitative reactions of some anions" is generally an experimental problem for the recognition of

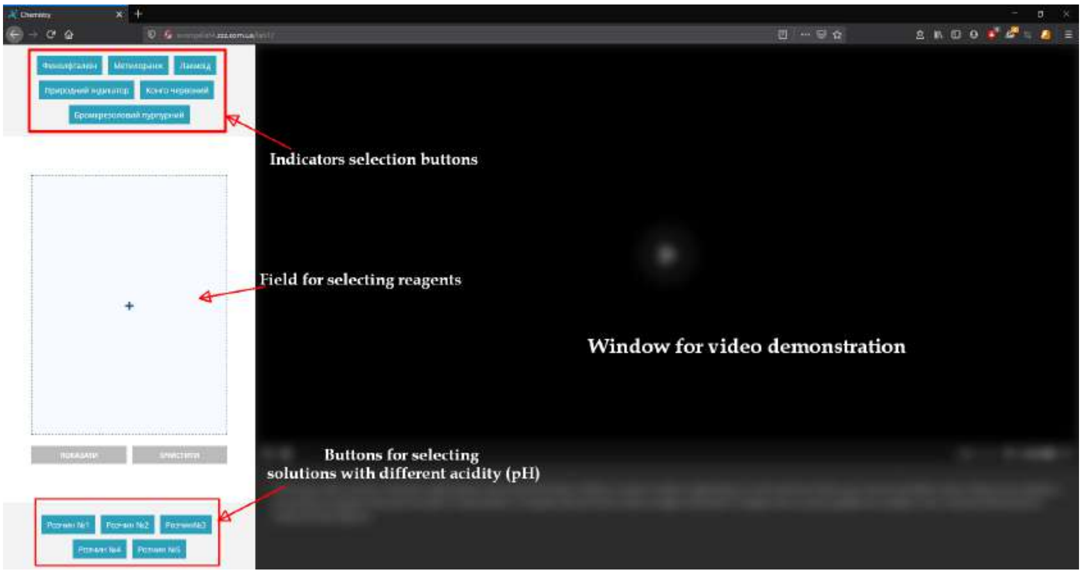

Figure 4: Location of the buttons of the main elements of the remote laboratory.

anions.

Both laboratory works are posted on the website http://distvlab.easyscience.education/, where they are available at the links http://distvlab.easyscience.education/Lab1 and http://distvlab.easyscience.education/Lab2.

5 RESULTS

The created virtual laboratory works were tested during chemistry lessons and optional classes in several educational institutions of the city of Kryvyi Rih during 2019: Kryvyi Rih Central City Lyceum, Kryvyi Rih Central City Gymnasium, schools No 66, No 21 and Kryvyi Rih College of National Aviation University of Ukraine. To do this, teachers used personal computers and netbooks, SMART Board interactive whiteboards, and smartphones and tablets.

Chemistry teachers especially noted the convenience of using virtual chemical laboratories to prepare for laboratory work or their partial replacement, and to organize effective independent work of students.

Students were asked a questionnaire with the following questions:

1. “Were you interested in using virtual chemical laboratories?”
2. “Was it easy for you to use virtual chemical laboratories?”
3. “Will virtual experiments help you better understand the theoretical material of the topic?”
4. “Did virtual chemistry labs help you better prepare for classroom practice work?”
5. “What did you like most about using virtual chemistry labs while studying chemistry?”

144 students took part in the survey. The results of the survey are shown in table 1.

The fifth question with an open answer was often answers by students, which can be formulated as: “non-standard approach to the organization of lessons”, “unusual and novelty of the use of virtual chemical laboratories”, “the possibility to make experiments without time or strict responsibility for the quality of individual actions”, “the possibility to independently make experiments as you want or interesting”, “the possibility to prepare at home, especially if you missed the lesson”. According to the observations of teachers involved in the experiment, the use of virtual chemistry laboratories increased students’ desire to experiment and reduced their fear of making mistakes during the experiment, making erroneous conclusions, and so on. This was evidenced by the high results demonstrated by students in performing practical work and experimental problems within the topic “Solutions”.

Thus, the majority of students noted a positive effect from the use of VCL primarily for practical work preparation, as well (a slightly lower percentage) in the acquisition of theoretical knowledge. For the vast majority of students, VCL was an interesting means of chemistry learning (perhaps due to novelty and non-standard), but a smaller percentage of students noted the ease of use of VCL, due to the same novelty for students, and therefore lack of skills in using

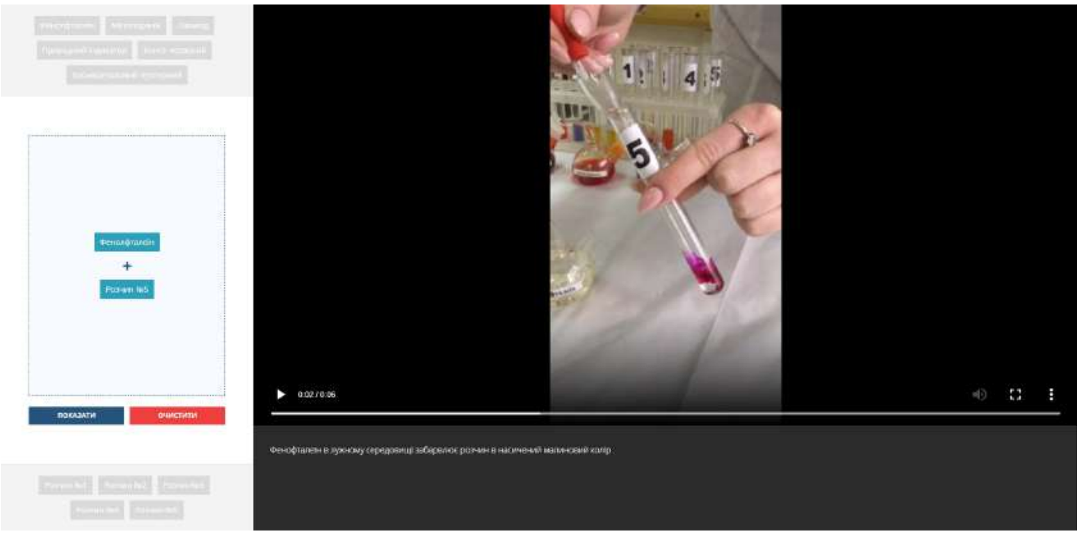

Figure 5: Remote chemical laboratory operation: selected buttons “Phenolphthalein” and “Solution No 5”.

Table 1: The results of student surveys.

Number of question	Answers to questions				
	“No”	“Rather no”	“Hard to say”	“Rather yes”	“Yes”
1	0	11 (7.6%)	52 (36.1%)	81 (56.3%)	
2	0	3 (2.1%)	18 (12.5%)	56 (38.9%)	67 (46.5%)
3	0	6 (4.2%)	14 (9.7%)	45 (31.2%)	79 (54.9%)
4	0	4 (2.8%)	13 (9%)	38 (26.4%)	89 (61.8%)

these teaching tools.

6 CONCLUSIONS

1. The learning research activities are an integral part of a quality educational process, especially in the study of natural sciences. The learning research activity differs from ordinary learning in that it requires an active cognitive position based on the internal search for answers to any question related to the understanding and creative processing of information, action through “trial and error”, and from scientific research it differs, first of all, in the results – the acquisition of subjectively new knowledge, the formation of research skills and other personality traits of students.
2. One of the varieties of learning research activities of students in chemistry is experimental chemical problems – a separate type of chemical problems, the solution of which is necessarily accompanied by the practical implementation of a chemical experiment.
3. Experimental chemical problems are characterized by the methodological feasibility of their use in various types of lessons, at different stages of a lesson and in extracurricular work.
4. One of the most important and integral topics in the school course of chemistry is the topic “Solutions” – while studying this topic, students consolidate knowledge of general and inorganic chemistry, acquire skills to perform experiments, gain theoretical and practical basis for further study of chemistry.
5. Pre-profile chemistry training contains a significant amount of experimental activity of students, and one of the ways to overcome the contradiction between the need to carry out a training chemical experiment and the lack of sufficient time, necessary equipment and reagents, the use of virtual chemical laboratories — special computer programs that make it possible to simulate the physical chemical phenomena or to conduct experiments without direct contact with a real chemicals set or the complete absence thereof.
6. Virtual chemical laboratories are, first of all, unique simulators – tools that allow users to test the algorithm of actions, to trace the logic of certain laboratory operations during the experiment, to practice skills of collecting and recording the necessary data, experimental results and

more. Remote virtual chemical laboratories have the advantage of conducting qualitative experiments, and simulation VCL – quantitative chemical experiments.

7. Virtual chemical laboratories in some cases can be used as a replacement for a real chemical experiment, if for some reason it's implementation is impossible.

8. Virtual chemical laboratories provide an opportunity to safely and economically implement the development of research competencies of students through the use of experimental chemical problems, which can be performed entirely in virtual mode or in simulator mode with subsequent implementation in the form of a naturaly experiment.

9. Virtual chemical laboratories are a rather labile learning tool that can be used at almost any stage of the lesson: at the beginning, at the stage of learning new knowledge, at the stage of consolidation of knowledge and at the stage of testing, as well as for independent and homework. In the case of proper organization of work with them, the student has the opportunity to perform learning research at any time and in any place.

10. The best option for quality support of learning research activities of students in chemistry by solving experimental chemical problems (including distance learning) in the study of topic "Solutions" is a combination of two types of virtual chemical laboratories – remote (for qualitative experiments) and simulation (for quantitative experiments).

11. Currently, a set of virtual laboratory works has been created, consisting of seven problems in the simulation VCL Virtual Lab and two experimental problems in the remote VCL. Currently, a set of virtual laboratory works has been created, consisting of seven problems in the simulation VCL Virtual Lab and two experimental problems in the remote VCL.

12. The created virtual laboratory works were introduced into the educational process of several educational institutions in Kryvyi Rih during 2019 and received mostly positive feedback from both chemistry teachers and students. This makes it possible to say that virtual chemical laboratories have a high potential for organizing and improving the learning research activities of students in chemistry while studying the topic "Solutions" and need further improvement taking into account the results of its implementation in the school educational process.

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Using Dynamic Vector Diagrams to Study Mechanical Motion Models at Agrarian University with GeoGebra

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Abstract: This article is devoted to study of effectiveness of one of the visualization options we use when teaching the students of an agricultural university the basics of math modeling. The main goal of this research is to test the hypothesis that visibility and visualization improve the educational achievements of students if for visualization we use the dynamic vector diagrams of characteristics of mechanical movement (in particular, these are velocity and acceleration or the acting force). There are discussion of the methodology and examples of the use of dynamic vector diagrams when teaching the basics of mathematical modeling. We described how our students are computing and plotting graphs and dynamic vector diagrams when they doing their practical learning exercises in math modeling and how they using them to analyze the mechanical motion of a body. Primarily we research and discuss the effectiveness of using dynamic vector diagrams. Other visualization options such as using plots of the dynamic characteristics of mechanical movement by Excel and GeoGebra was discussed earlier in (Flehantov and Ovsiienko, 2019). In this article we described our experience of using of dynamic vector diagrams in teaching the basics of math modeling at agrarian university and compared the research results were obtained with previous ones. Also we compare the educational achievements of students in the basics of math modeling were obtained by them using Excel and by GeoGebra software which allow to plot and study the dynamic vector diagrams much easy.

1 INTRODUCTION

Recently there are a lot of changes in education technologies: in fact we are living at a new time. Now it is clear that some of researches in the field of education that were made earlier are obsolete. The one of the main things today is the transition from verbal channel of communication in learning to visual. Although the scientists have not yet had time fully to study and investigate this process but the young people already have mastered all these.

The approach to teaching the basics of mathematical modeling (BMM) that this study focuses on is based on visualization (Ivanova et al., 2020) and it can be described by the saying: “I hear and forget. I see and remember. I do and understand” (Xunzi, 2020).

This article devoted to results of our research on the impact of visualization to teaching BMM with the use of popular mathematical computer program – the GeoGebra dynamic geometry system (GeoGebra, 2021; Kramarenko et al., 2020a). At first, we points out some researches that were the starting point for the hypothesis and objectives of this work.

The methodological principles of using ICT in the teaching of mathematical disciplines at universities we used were elaborated in (Bobyliev and Vihrova, 2021; Klochko and Bondarenko, 2013; Kramarenko et al., 2020b; Rakov, 2005; Tarasenkova et al., 2019; Tryus, 2005). Some important issues of the use of ICT in the educational process at the universities were shown in (Abdula et al., 2020; Bakum and Morozova, 2015; Polhun et al., 2021; Spivakovsky et al., 2019; Hrybiuk et al., 2014).

Note in passing that to using of Excel spreadsheets in the teaching of BMM which is also mentioned in

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this article were devoted to a number of scientific publications about an array of the some aspects of this direction. For review of the early studies may be of utility the works by Illia O. Teplytskyi (Teplytskyi and Semerikov, 2002; Teplytskyi, 2010; Semerikov et al., 2018).

We can't be said the same about the GeoGebra dynamic geometry system. There are many articles devoted to this software but most of them describe of only the capabilities and show some examples how to use it in teaching. As examples we can point out for publication by Osypova and Tatochenko (Osypova and Tatochenko, 2021) on improving the learning environment for future mathematics teachers with the use application of the dynamic mathematics system GeoGebra AR. In the article by Drushlyak et al. (Drushlyak et al., 2020) the methodology of formation of modeling skills based on a constructive approach was shown the on the example of GeoGebra. It shows the basic techniques for using GeoGebra in teaching and studying mathematics, with an emphasis on examples from geometry. Noteworthy alone is the article by Kyslova et al. (Kyslova et al., 2014) devoted to the problems of teaching higher mathematics for students of engineering specialties and to the creation of dynamic models in GeoGebra.

Caligaris et al. (Caligaris et al., 2015a,b) were concluded that using GeoGebra applets is an effective teaching methodology for teaching Calculus. Arbain and Shukor (Arbain and Shukor, 2015) noted that the students have more positive perception towards learning and have better learning achievement using GeoGebra. The article by Valdés y Medina and Medina Valdés (Valdés y Medina and Medina Valdés, 2015) is show in practice how the GeoGebra software can be used to exemplify the different mathematical concepts.

In addition let's we say that a lot of examples the using of GeoGebra software for teaching mathematics and science daily replenished on the GeoGebra website (GeoGebra, 2021; Hall and Lingefjard, 2016). It is also known that MS Excel has built-in functions for visualizing changes in calculated values just like GeoGebra has the built-in SpreadSheet component that allows you to partially perform the tasks the same of Excel. However, the using of these tools needs the results of the previous teaching of information technology which are not provided for curriculum of agrarian universities.

The problems of teaching the basics of mathematical modeling are closely related to the issues of applied orientation of mathematical (fundamental, natural sciences) disciplines. In this regard we note the researches (Blomhøj and Kjeldsen, 2006; Blomhøj and Jensen, 2007; Burghes, 1980; Finlay and King, 1986; Flores et al., 2016; Geiger et al., 2010; Kaiser et al., 2011; Kapur, 1982; Klymchuk et al., 2008; Lofgren, 2016; Oke, 1980; Schukajlow et al., 2018; Soloviev et al., 2019; Temur, 2012; Verschaffel and De Corte, 1997; Vos, 2011). There are some applied issues of mathematical modeling in agroengineering are considered in the textbook (Flehantov, 2006).

In general, despite a significant number of studies and publications, the problems of teaching the basics of mathematical modeling using ICTs still remain outside the attention of the integrated approach of researchers.

Our interest for the main topic of this research based on its practical importance for the training of modern agricultural production engineers, since "teaching the basics of mathematical modeling (BMM) is an important component in the training of modern agricultural production engineers. Its practical value is due to the fact that training on the basis of mathematical modeling can be an effective strategy in modern realities" (Flehantov and Ovsiienko, 2019). This research is a logical extension of article (Flehantov and Ovsiienko, 2019) where we also were tested the hypothesis that visualization of the dynamic characteristics of mechanical processes using GeoGebra improves the student's learning outcomes for BMM (in this article for visualize the dynamic characteristics of mechanical motion were used graphs of trajectories of moved bodies in Excel and GeoGebra).

After the experiment with the simultaneous use of Excel and GeoGebra we were conducted in the fall of 2018 we observed a reversal of negative dynamics in the results of training of BMM the students of engineering and technical specialties of the Poltava State Agrarian Academy, Poltava, Ukraine (PSAA) (2014 – 75.8; 2015 – 75.6; 2016 – 72.6; 2017 – 70.1). According to the results of the fall semester of 2018 the average score in this discipline was 74.8 (Flehantov and Ovsiienko, 2019). At the same time in the experimental groups E (Excel users) and G (GeoGebra users) we obtained almost the same average values of student performance, equal to 73.4 and 73.7, in fact at the level of 2016 (taking into account the permissible statistical error). Whereas in the EG group (simultaneous use of Excel and GeoGebra) the mean value was 77.4. You can try to explain this result by the fact that already in 2017 we recognized the negative trend of lowering student performance as a problem and showed some enthusiasm in solving it. The results of the EG group obtained on the basis of the assumption of the leading role of visualization in teaching the basics of mathematical modeling with the simultaneous use of Excel and GeoGebra showed a statistically significant difference from the results of the E and G. The average score in the EG group exceeded even quite high learning outcomes of 2014 and 2015. Thus it can be already considered now as a fact that the visualization of modeling results creates additional conditions for improving students' knowledge taking into account the specifics of their professional training.

The main goal of this article is to test with new idea the hypothesis that visibility and visualization improve the educational achievements of students of an agricultural university when studying the basics of mathematical modeling. This research is devoted to the study of the effectiveness of one of the visualization options, which we use when teaching the basics of mathematical modeling to students of an agricultural university. As a way of visualization in this research were used the dynamic vector diagrams of the characteristics of mechanical movement. Our students build these diagrams when they perform practical educational tasks in mathematical modeling, and use them to analyze the mechanical motion of a body thrown at an angle to the horizon, as shown in this article. Further in this article we describe the experience of using dynamic vector diagrams in teaching the basics of mathematical modeling, compare the obtained research results with previous ones and also compare the educational achievements of students in the basics of mathematical modeling which were obtained by them using Excel and GeoGebra.

2 EXPERIMENT DESCRIPTION

2.1 General Design

This article based on the results of the pedagogical experiment that was performed by authors in September-November 2019 and in September-November 2020. The experiment was enrolled by 167 students of the Faculty of Engineering and Technology. The provided sample size makes it possible with ANOVA method to establish significant differences between group means at the level of 1 point: at a significance level of 0.05, number of groups 3 and a power of 80% the required sample size for groups is at least 50 units.

At the beginning of the experiment the students was attended were categorized into three groups called E, G and EG; for this we used the technique described in (Flehantov and Volchkova, 2010) which allow us to initially form groups homogeneous by the criterion of academic performance (Flehantov and Volchkova, 2012). The group E used Excel spreadsheets during the training of BMM. The group G used the GeoGebra. The group EG used simultaneously Excel and GeoGebra. Throughout the entire study period, these groups were not permanent: students remaining in their academic group could arbitrarily migrate from one experimental group to another. The final composition of the groups was fixed at the end of the experiment. All groups underwent BMM training in a single program using the methodology of a differentiated approach to training presented in (Flehantov and Ovsiienko, 2019). The training time in all groups was the same. Each of group was offered complete the same learning task has a direct connection with the topics important in the training of engineers of agrarian production. Learning outcomes of the students of groups E, G and EG were evaluated on the results of solving a set of typical tasks for individual independent work.

The main learning task for all students was: modeling the movement of spherical body was thrown at an angle to the horizon, with taking into account air resistance, gravitational interaction, electrostatic interaction, magnetic interaction, etc.

We have applied a differentiated approach in learning by doing considered the gradual construction of end-to-end mathematical models (MM) of several levels of complexity their computer implementation and study through numerical calculus. The purpose of these works is to familiarize students with the practice of creating MM, the construction of computational circuits and their computer implementation, forming the skills of conducting a computer experiment and interpreting its results.

The typical task for the students' practice was: create MM of free motion of the body in the gravity field and find its solution. Further we build a calculation algorithm and in the environment of the selected software implement the calculation and computing scheme for MM, conduct a computing experiment and draw conclusions from it. The basic of such MM is the classical model of the motion of a body thrown at an angle to the horizon well known from the school physics course. It's generalized in the first year of engineering faculties of agricultural universities in the study of the discipline "Physics", also used in "Higher Mathematics" to illustrate the physical meaning of the solutions of differential equations and in the second year in "Theoretical Mechanics". Several previously published articles have considered some options for solving this training exercise using Excel (Teplytskyi, 2010; Horda and Flehantov, 2015) and MathCAD (Flehantov and Antonets, 2017). A similar technique was also used by authors for implementation a differentiated approach in teaching of BMM (Flehantov and Ovsiienko, 2016). The algorithm for solving this learning problem has several stages are described in detail in the article (Flehantov and Ovsiienko, 2019).

The students' final learning outcomes were evaluated after completing the full course of discipline. We also retained the methodology for assessing student academic achievements: the learning outcomes of students were assessed on a 100-point scale (Flehantov and Ovsiienko, 2019) on the basis of the performance results of an individual independent learning problems.

2.2 Mathematical Model Creation

It's assumed that the students should use the competencies they acquired were learning "Higher Mathematics", "Physics", "Theoretical Mechanics", "Applied Mathematics", etc when constructing and analyzing math models.

The algorithm of actions by students when they performing the learning exercises is detailed in (Flehantov and Ovsiienko, 2019). The students creates three mathematical models (MM) in different levels of complexity named MM I, MM II and MM III using the mechanical meaning of the derivative and analyzing the vector equations of the resultant forces acting on the body in three different cases. The MM I model describes the motion of a body thrown at an angle to the horizon without air resistance. The MM II model describes the motion of a spherical body thrown at an angle to the horizon with air resistance but no rotation. The MM III model additionally takes into account the Magnus effect – the Magnus force arising from the rotation of the body during the translational-rotational motion of the body in dense medium. An approximate line of reasoning follows next.

Based on the mechanical meaning of the derivative all models will include these two ordinary differential equations of the first order:

$$\frac{dx}{dt} = v_x, \quad \frac{dy}{dt} = v_y. \tag{1}$$

If a body thrown at an angle to the horizon is affected only by gravity force $\overline{F}_T = \left(F_1^x, F_1^y\right)$ then $F_1^x = 0$ and $F_1^y = -mg$. Therefore, two more equations will be added to MM I:

$$\frac{dv_x}{dt} = 0, \quad \frac{dv_y}{dt} = -g. \tag{2}$$

The MM I is described by four differential equations (1) and (2). This elementary model describes the motion of a body thrown at an angle to the horizon in the field of gravity force without air resistance. It corresponds to the first (lowest) level of difficulty in BMM training.

The MM II is the second level of complexity. In this case the equivalent force acting on the body is $\overline{F}_2 = \overline{F}_T + \overline{F}_r$, where $\overline{F}_r = -k_2 v^2 \frac{\overline{v}}{v}$ – force of air resistance, $v = \sqrt{v_x^2 + v_y^2}$ – velocity of the body, k_2 – factor of medium resistance. From here: $F_2^x = -k_2 v_x v$, $F_2^y = -g - k_2 v_y v$. Thus in addition to (1) MM II will also include the following two equations:

$$\begin{aligned} \frac{dv_x}{dt} &= -\frac{k_2}{m} v_x \sqrt{v_x^2 + v_y^2}, \\ \frac{dv_y}{dt} &= -g - \frac{k_2}{m} v_y \sqrt{v_x^2 + v_y^2}. \end{aligned} \tag{3}$$

MM III corresponds to the third (highest) level of complexity in our training program. In this case there will be an equivalent force $\overline{F_3} = \overline{F}_T + \overline{F}_r + \overline{F}_M$, where $\overline{F}_M = -k_3 v^2\,(\overline{\omega} \times \overline{v})$, k_3 – coefficient related to the Magnus effect. From here: $F_3^x = -k_2 v_x v \pm k_3 v_y v$, $F_3^y = -g - k_2 v_y v \mp k_3 v_x v$ (the upper sign "+" is on if body rotate clockwise, the lower sign "–" is on if body rotate counterclockwise). Therefore in addition to (1) MM III will include next two equations:

$$\begin{aligned} \frac{dv_x}{dt} &= \left(-\frac{k_2}{m} v_x \pm \frac{k_3}{m} v_y\right) \sqrt{v_x^2 + v_y^2}, \\ \frac{dv_y}{dt} &= -g + \left(-\frac{k_2}{m} v_y \mp \frac{k_3}{m} v_x\right) \sqrt{v_x^2 + v_y^2}. \end{aligned} \tag{4}$$

In mathematical models we built the following notation used:

$x = x(t)$, $y = y(t)$ – coordinates of center of the body at the point of time t, s;

$v_x = v_x(t)$, $v_y = v_y(t)$ – the body's velocity projections on axis of reference at time t, m/s;

g – gravity acceleration, m/s^2; m – mass of the body ($m \neq 0$), kg;

$k_2 = \frac{1}{2} C_D \rho S$ – factor of medium resistance, kg/m;

$k_3 = \frac{1}{2} C_L \rho S$ – factor of Magnus force, kg/m;

C_D – drag coefficient, depends on body shape and characteristics of medium (for sphere in air $C_D = 0.47$), no the unit of measurement;

C_L – coefficient characterizing the Magnus effect depends on the shape of the body, the quality of its surface and the properties of medium (for sphere $0.1 \leq C_L \leq 0.6$), no the unit of measurement;

ρ – ambient density (for air $= 1,213$), kg/m^3;

S – normal cross-sectional area of the body relative to direction of motion, m^2; in general $S = S(t)$, for a spherical body $S = \pi r^2$, where r – radius of the sphere, m.

2.3 Performing the Learning Exercises by Excel (Group E)

This part of our research we presented here in a concise statement. A detailed description of the relevant methodology and other explanations are presented in the article (Flehantov and Ovsiienko, 2016).

The calculation scheme of the computer implementation of MM I (1), (2) in the MS Excel environment is obtained directly from its analytical solution (Klochko and Bondarenko, 2013; Kalitkin and Koryakin, 2013):

$$v_{xi} = v_{0x}, v_{yi} = v_{0y} - gt_i, x_i = x_0 + v_{0x}t_i, \\ y_i = y_0 + v_{0y}t_i - \frac{gt_i^2}{2}, i = \overline{0,\ n} \tag{5}$$

The following notation used here:

x_0 , y_0 – initial coordinates the center of the body, m;

v_0 – initial velocity of the body, m/s;

α_0 – initial angle to the horizon which the body is thrown, radians;

$v_{0x} = v_0 \cos\alpha_0$, $v_{0y} = v_0 \sin\alpha_0$ – projections the initial velocity of the body v_0;

$t_i = i \cdot \Delta t, t_i \in [0,\ t_M], i = \overline{0,\ n}$ – the time points of observation; i – numbers of body observation positions (fixation points); n – numbers of fixation points; $\Delta t = t_M/n$ – time between the time points of observation, s; t_M – simulation time, s;

$x_i = x(t_i)$, $y_i = y(t_i)$ – coordinates the center of the body in the time point t_i;

$v_{xi} = v_x(t_i)$, $v_{yi} = v_y(t_i)$ – projections velocity of the body in the time point t_i; $v_i = \sqrt{v_{xi}^2 + v_{yi}^2}$ – velocity of the body in the time point t_i.

Models MM II (1), (3) and MM III (1), (4), unlike MM I, do not allow an analytical solution. Therefore the computational schemes of the models are based on numerical methods.

The computational scheme for MM II according to the Euler method for the fist order ODE systems is (Kalitkin and Koryakin, 2013):

$$v_{x\,i+1} = v_{xi} - \frac{k_2}{m} v_{xi} v_i \Delta t, \\ v_{y\,i+1} = v_{yi} - \left(g + \frac{k_2}{m} v_{yi} v_i\right) \Delta t, \\ x_{i+1} = x_i + v_{xi}\Delta t, y_{i+1} = y_i + v_{yi}\Delta t. \tag{6}$$

For MM III the calculation scheme is the same but the first two equations in (6) need to replace by following ones:

$$v_{x\,i+1} = v_{xi} - \left(\frac{k_2}{m} v_{xi} v_i - rot \frac{k_3}{m} v_{yi} v_i\right) \Delta t, \\ v_{y\,i+1} = v_{yi} - \left(g + \frac{k_2}{m} v_{yi} v_i + rot \frac{k_3}{m} v_{xi} v_i\right) \Delta t. \tag{7}$$

The initial data for calculations by formulas (5), (6), (7) are the values of parameters g, x_0, y_0, v_0, α_0, r, m, ρ , C_D, C_L, t_0, t_M, n and rot. The rot parameter can take three fixed values: (–1) – means counterclockwise rotation, (+1) – clockwise rotation, 0 – no rotation. Model MM III with $rot = -1$ further we denote as MM III–, and with $rot = +1$ – as MM III+. With $rot = 0$ the model MM III is equally matched to model MM II.

Numerical calculations by formulas (5), (6), (7) are performed by standard MS Excel tools. As a result the next tables of values are obtained: i, t_i, x_i, y_i, v_{xi}, v_{yi}, v_i, α_i, E_{ki}, E_{pi}, where $\alpha_i = arctg \frac{v_{yi}}{v_{xi}}$ – the angle of the trajectory of the body to the horizon; $E_{ki} = \frac{mv_i^2}{2}$ – kinetic energy of translational motion of the body; $E_{pi} = mgy_i$ – the potential energy of the body.

Figure 1 demonstrates of the data input interface of the models MM I, MM II and MM III in MS Excel. Figure 2 displays a part of table of calculations according to MM III for values of input parameters presented in figure 1.

	A	B	C	D	E	F
1	**Model of dynamics of translational-rotational motion**					
2	**of a body in a dense medium**					
3						
4	g=	9,81	m/s2	d=	0,24	m
5	x0=	0	m	m=	0,68	kg
6	y0=	0	m	CD=	0,47	
7	alpha0=	45	degrees	ro=	0	kg/m3
8	v0=	9,3	m/s	S=	0,045239	m2
9	v0x=	6,576093	m/s	k2=	0	kg/m
10	v0y=	6,576093	m/s	k2/m=	0	1/m
11	Time of modeling:			CL=	0,35	
12	Start t0=	0,0000	s	Direction of rotation:		
13	End t=	1,3914	s		0	
14	TM=	1,3914	s	k3=	0	kg/m
15	deltaT=	0,013914	s	k3/m=	0	1/m

Figure 1: Interface for input of initial data for math models MM I – MM III in MS Excel.

Figure 3 and figure 4 depicts the plots of trajectories and velocities of the bodies calculated for all the models under consideration. Visual comparison and analysis of such graphs allows students to formulate meaningful conclusions about the characteristics of those movements in various conditions.

In this way, the students using Excel analyze the obtained numerical results and graphs by changing the input parameters of the models. Thus, they can to study the motion of body thrown at an angle to the

	A	B	C	D	E	F	G
17	i	ti, s	vxi, m/s	vyi, m/s	vi, m/s	xi, m	MM I
18	0	0	6,576093	6,576093	9,3000	0,00000	0
19	1	0,013914	6,576093	6,439597	9,2040	0,09150	0,0915
20	2	0,027828	6,576093	6,3031	9,1090	0,18300	0,1811
21	3	0,041742	6,576093	6,166604	9,0151	0,27450	0,268802
22	4	0,055656	6,576093	6,030108	8,9223	0,36600	0,354604
23	5	0,06957	6,576093	5,893611	8,8306	0,45750	0,438507
111	93	1,294002	6,576093	-6,11807	8,9820	8,50948	0,384657
112	94	1,307916	6,576093	-6,25456	9,0755	8,60098	0,29953
113	95	1,32183	6,576093	-6,39106	9,1701	8,69248	0,212504
114	96	1,335744	6,576093	-6,52756	9,2657	8,78398	0,123579
115	97	1,349658	6,576093	-6,66405	9,3624	8,87548	0,032755
116	98	1,363572	6,576093	-6,80055	9,4600	8,96698	-0,05997
117	99	1,377486	6,576093	-6,93704	9,5586	9,05848	-0,15459
118	100	1,3914	6,576093	-7,07354	9,6582	9,14998	-0,25111

Figure 2: Fragment of the table of calculations for MM I in MS Excel.

horizon in various conditions to answer by itself to control questions and to prepare to exam.

2.4 Performing the Learning Exercises by GeoGebra (Group G)

The description and implementation of the mathematical model of the mechanical motion of bodies in GeoGebra has its own characteristics, which we were mentioned in the work (Flehantov and Ovsienko, 2019).

The main feature of GeoGebra is an algebraic-geometric approach to the description of mathematical objects. To solve MM I, MM II and MM III by GeoGebra is much easier than by Excel. In GeoGebra is not necessary to build and describe in detail (step by step) complex calculation schemes for solving systems of differential equations of models. All you need is write down the models following the GeoGebra syntax and use the built-in NSolveODE command for numerical solutions of first order differential equations (wiki.geogebra.org, 2020).

The MM I represents in GeoGebra by formulas (1) and (2) as follow (all commands are entered through the command line of the program). From now on the GeoGebra's notation used:

```
x1'(t,x1,y1,vx1,vy1) = vx1
y1'(t,x1,y1,vx1,vy1) = vy1
vx1'(t,x1,y1,vx1,vy1) = 0
vy1'(t,x1,y1,vx1,vy1) = -g
```

Next input command used to solve the system of differential equations above by GeoGebra is:

```
NSolveODE({x1',y1',vx1',vy1'},
                    0,{x0,y0,vx0,vy0},TM)
```

The NSolveODE command implements the 4th order numerical Runge-Kutta method in GeoGebra command line (GeoGebra, 2021; Hall and Lingefjard, 2016; wiki.geogebra.org, 2020). It generates the numerical solution the Cauchy problem per segment $t \in [0, t_M]$ with initial conditions `{x0, y0, vx0, vy0}` and other input parameters of model – tabulates four functions $x_1 = x_1(t)$, $y_1 = y_1(t)$, $v_{x1} = v_{x1}(t)$, $v_{y1} = v_{y1}(t)$ (according to the number of unknown functions in the model). The resulting solutions are assigned with identifiers called `numericalIntegral` with sequential numbering (according to the order of unknown functions in the system of differential equations), namely:

```
numericalIntegral1 = x1(t)
numericalIntegral2 = y1(t)
numericalIntegral3 = vx1(t)
numericalIntegral4 = vy1(t)
```

The same way, the MM II by formulas (1) and (3) is represented as:

```
x2'(t,x2,y2,vx2,vy2)=vx2
y2'(t,x2,y2,vx2,vy2)=vy2
vx2'(t,x2,y2,vx2,vy2)=-k_2*vx2
                       *sqrt(vx2^2 + vy2^2)/m
vy2'(t,x2,y2,vx2,vy2)=-g - k_2*vy2
                       *sqrt(vx2^2 + vy2^2)/m
```

We find the solution of the MM II by the command:

```
NSolveODE({x2',y2',vx2',vy2'},0,
           {x0,y0,vx0,vy0},TM)}
```

This command also gives us four functions – MM II solution:

```
numericalIntegral5 = x2(t)
numericalIntegral6 = y2(t)
numericalIntegral7 = vx2(t)
numericalIntegral8 = vy2(t)
```

Same as previous the MM III by formulas (1) and (4) is represented next way:

```
x3'(t,x3,y3,vx3,vy3)=vx3
y3'(t,x3,y3,vx3,vy3)=vy3
vx3'(t,x3,y3,vx3,vy3)=-k_2*vx3*
sqrt(vx3^2+vy3^2)/m+rot*k_3*vy3*
sqrt(vx3^2+vy3^2)/m
vy3'(t,x3,y3,vx3,vy3)=-g-k_2*vy3*
sqrt(vx3^2+vy3^2)/m-rot*k_3*vx3*
sqrt(vx3^2+vy3^2)/m
```

And the MM III solution we will find by the command:

```
NSolveODE({x3',y3',vx3',vy3'},0,
           {x0,y0,vx0,vy0},TM)}
```

This way we have got the MM III solution:

```
numericalIntegral9 = x3(t)
numericalIntegral10 = y3(t)
numericalIntegral11 = vx3(t)
numericalIntegral12 = vy3(t)
```

Now then we have saw that due to the uniformity of actions the solutions of all three models are obtained by GeoGebra much faster than with Excel.

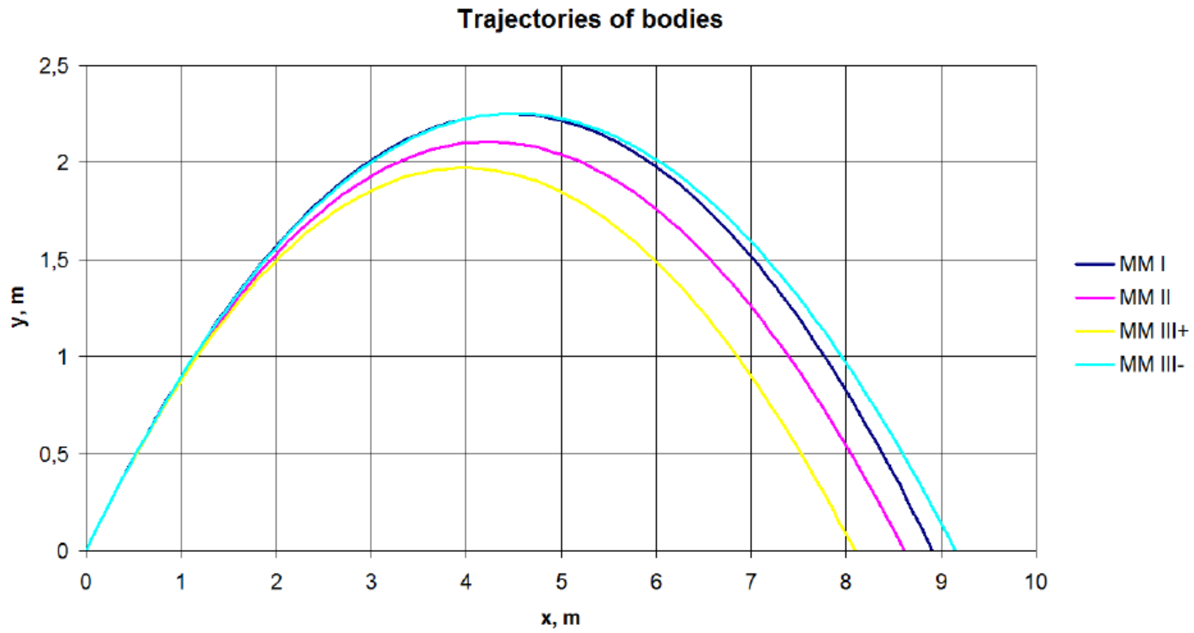

Figure 3: Plots of trajectories of bodies for MM I – MM III in MS Excel.

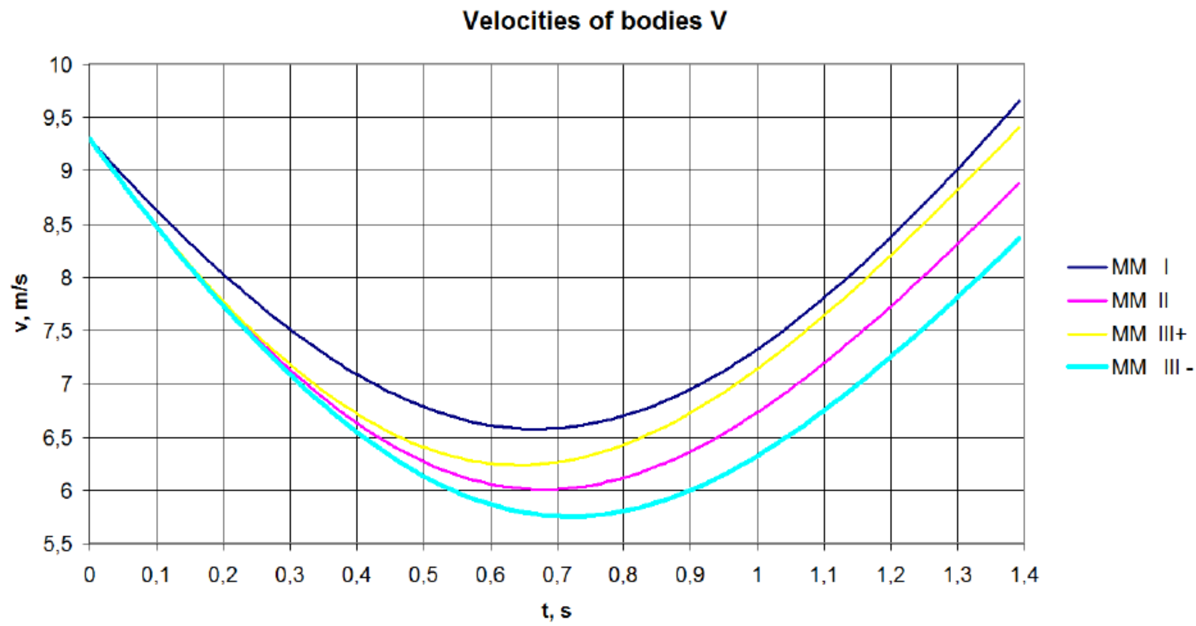

Figure 4: Graphs of velocities of bodies for MM I – MM III in MS Excel.

Also, if the students have this solutions, than they can fast and easy visualizing dynamic characteristics of the math models by GeoGebra as it shown in figure 5.

The trajectories of bodies visualized in GeoGebra according to the models MM I, MM II and MM III using the values of functions `x1(t)`, `y1(t)`, `x2(t)`, `y2(t)`, `x3(t)`, `y3(t)` as coordinates for three moving points `A=(x1, y1)`, `B=(x2, y2)` and `C=(x3, y3)` respectively. Figure 5 shows the trajectories of spherical bodies thrown at an angle to the horizon (for three different values of initial angles) for models: MM I – red line; MM II – green line; MM III – blue line. These colors we will use for convenience in all figures next. The current values of the basic parameters of the models are shown in the figure on the interactive controls. The arrows shown in figure 5 are vectors

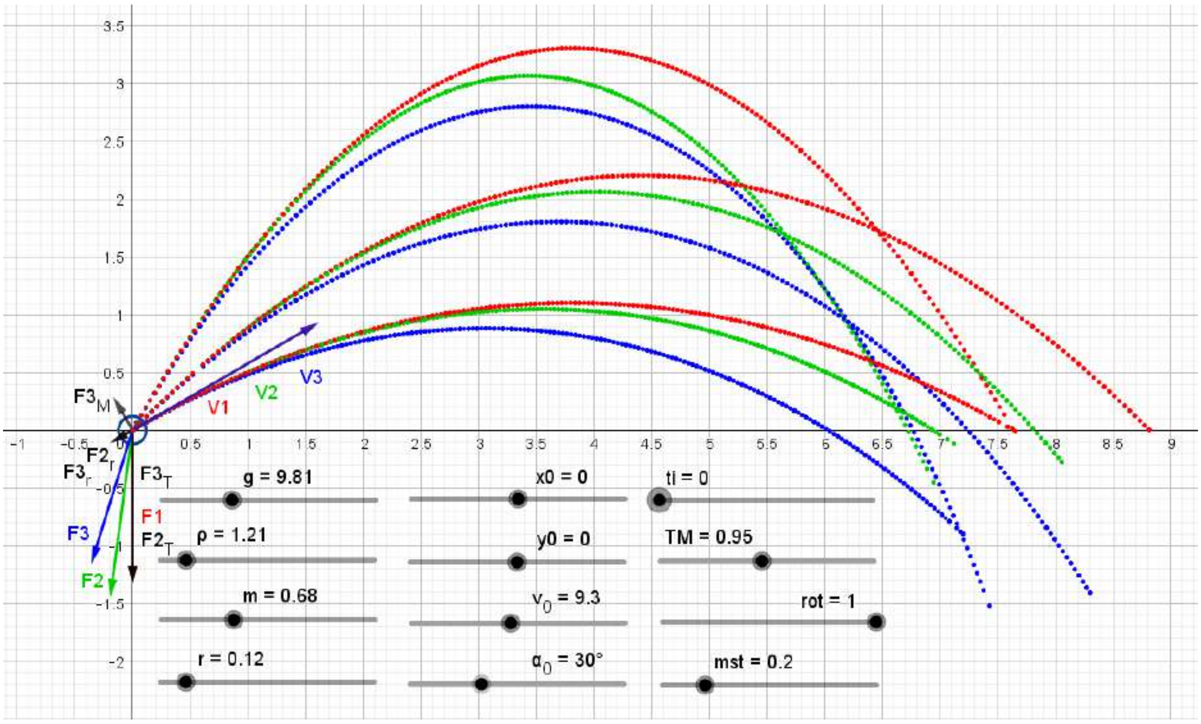

Figure 5: Graphs of trajectories of bodies for MM I – MM III in GeoGebra for different values of initial angles α_0: 30°, 45° and 60°.

of velocities and vectors of forces acting on the bodies as they moves.

As we see, the GeoGebra software has better graphics than Excel and provides additional visualization capabilities. In particular, using the animation feature, the students can observe with GeoGebra dynamic graphing of functions – a computer simulation the process of mechanical movement of the body. By using dynamic zooming in the GeoGebra window the students can to view graph details on a larger scale. Figure 6 and figure 7 shows some fragments trajectories of bodies for opposite directions of body rotation which controlled in MM III by parameter *rot*. The plots in these figures are presented for compare one to others as an example.

Vectors of velocities of the bodies in figure 6 and figure 7 describes in GeoGebra as follow: `V1=Vector(A, A3)`, where `A3=(x(A1), y(A2))`, `A1=(x(A)+mst*y(Point(numericalIntegral3, c)), y(A))` or `A1=(x(A) + mst*vx1,y(A))`, `A2=(x(A),y(A)+mst*y(Point(numericalIntegral4,c)))` or `A2=(x(A),y(A)+mst*vy1)`; `V2=Vector(B,B3)`, where `B3=(x(B1),y(B2))`, `B1=(x(B)+mst*y(Point(numericalIntegral7, c)), y(B))` or `B1=(x(B)+mst*vx2,y(B))`, `B2=(x(B),y(B)+mst*y(Point(numericalIntegral8,c)))` or `B2=(x(B),y(B)+mst*vy2)`; `V3=Vector(C,C3)`, where `C3=(x(C1),y(C2))`, `C1=(x(C)+mst*y(Point(numericalIntegral11, c)), y(C))` or `C1=(x(C)+mst*vx3,y(C))`, `C2=(x(C),y(C)+mst*y(Point(numericalIntegral12,c)))` or `C2=(x(C),y(C)+mst*vy3)`;

`mst` – scale factor for displaying vectors used for convenience because in normal scale they can be disproportionate in size – some much larger than others (in figure 5, figure 6 and figure 7 value of `mst = 0.1`).

Vectors of forces acting on the bodies and their resultants for three different models are represented in figure 6 and figure 7 (in order of construction). Indices 1, 2 and 3 are referring to models MM I, MM II and MM III respectively:
`F1=Vector(A,F1_1)`, where `F1_1=(x(A),y(A)-mst*m*g)`;
`F2=Vector(B,F2_3)`, where `F2_3=F2_1 + F2_2-B`, `F2_1=(x(B),y(B)-mst*m*g)`, `F2_2=(x(B) + mst*F2x_r, y(B) + mst*F2y_r)`, `F2x_r= -k_2*vx2*sqrt(vx2^2 + vy2^2)`, `F2y_r= -k_2*vy2*sqrt(vx2^2 + vy2^2)`; `F2_T= Vector(B,F2_1)`; `F2_r= Vector(B,F2_2)`;
`F3= Vector(C, F3_5)`, where `F3_5=F3_3+F3_4-C`, `F3_3= F3_1 + F3_2-C`, `F3_4= (x(C) + mst*F3x_M, y(C) + mst*F3y_M)`,

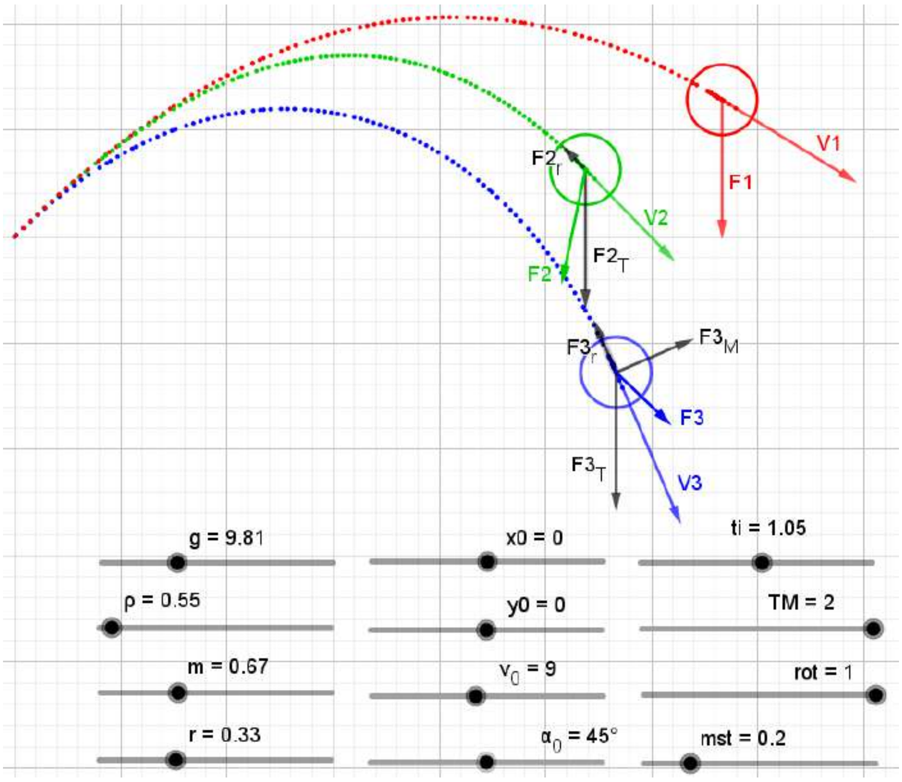

Figure 6: Fragments of trajectories of bodies plotted in GeoGebra for MM I – MM III with `rot=+1`.

```
F3_1= (x(C), y(C) - mst*m*g),
F3_2= (x(C) + mst*F3x_r, y(C) + mst*F3y_r),
F3x_r=-k_2*vx3*sqrt(vx3^2 + vy3^2),
F3y_r=-k_2*vy3*sqrt(vx3^2 + vy3^2),
F3x_M=rot*(-k_3)*vy3*sqrt(vx3^2 + vy3^2),
F3y_M=rot*k_3*vx3*sqrt(vx3^2 + vy3^2).
```

Vectors of the gravity force $F3_T$, the force of air resistance $F3_r$ and the Magnus force $F3_M$ for model M III are represented as follows:

```
F3_T=Vector(C,F3_1),
F3_r=Vector(C,F3_2),
F3_M=Vector(C,F3_4).
```

Thus, the students implements the mathematical models MM I, MM II, MM III in the GeoGebra environment with the help of this simple mathematical apparatus based on the method of coordinates and elementary vector algebra.

Figure 8, figure 9 and figure 10 shows the dynamic vector diagrams which our students are plotting in GeoGebra and studying by computer simulation. On them in dynamics are displayed the vector diagrams of the velocities of bodies and their projections in different phases of motion according to the models MM I, MM II, MM III. These diagrams are dynamic and interactive because they automatically changes if you use the sliders shown in the figure to set new values for the model inputs. At moment represented results at time `ti = 1.04` s for the following values of the initial parameters: `g=9.81`, `ro=1.213`, `m=0.68`, `r=0.12\verb`, `x0=0`, `y0=0`, `v0=9.3`, `alpha0=45`, `rot=1`, `mst=0.1`.

The using of dynamic vector diagrams for visualizing dynamic characteristics to study and analyze mechanical movement when teaching students the basics of mathematical modeling is the main difference between this studies from the previous ones. The computer simulation and the studying dynamic vector diagrams of velocities of bodies allows for students interactively observe changes that occur with vectors of velocities depending on changes of values of various model parameters and study and compare the dynamic characteristics of motion of the bodies in different phases of its movement.

The students simultaneously study and analyze the corresponding plots of velocities of the bodies and their projections on the coordinate axes similar to those shown in figure 11 and figure 12. In contrast to vector diagrams these plots better shows how changes the absolute value of velocity of the body. The analysis allow to us to find the direction of movement of body at different times. At the same time dynamic vector diagrams of velocities give us a clear visual

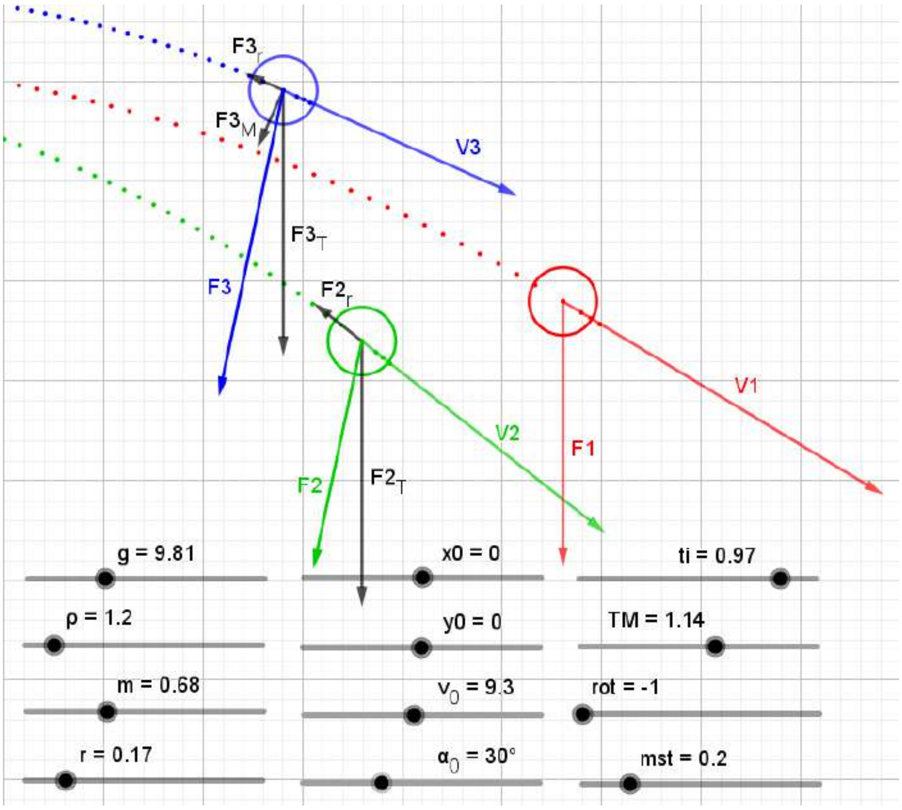

Figure 7: Fragments of trajectories of bodies plotted in GeoGebra for MM I – MM III with `rot=-1`.

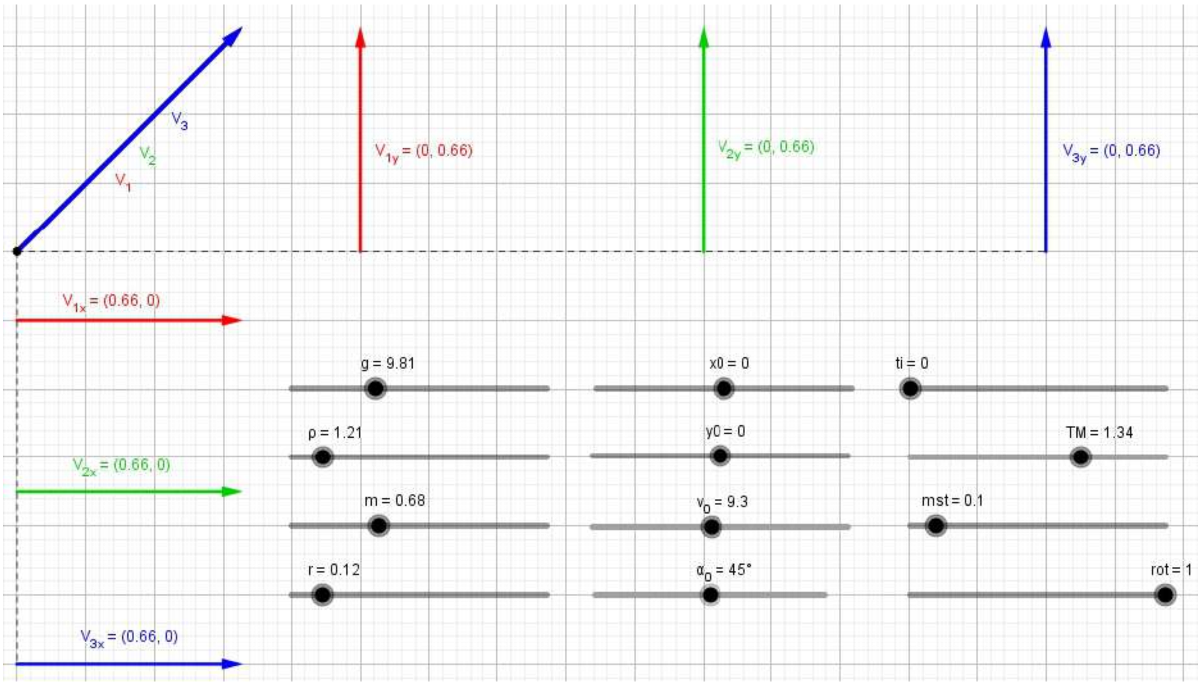

Figure 8: The dynamic vector diagram of velocities of bodies plotted in GeoGebra for MM I – MM III+ (clockwise rotation) at start of movement: ti=0, $rot = +1$.

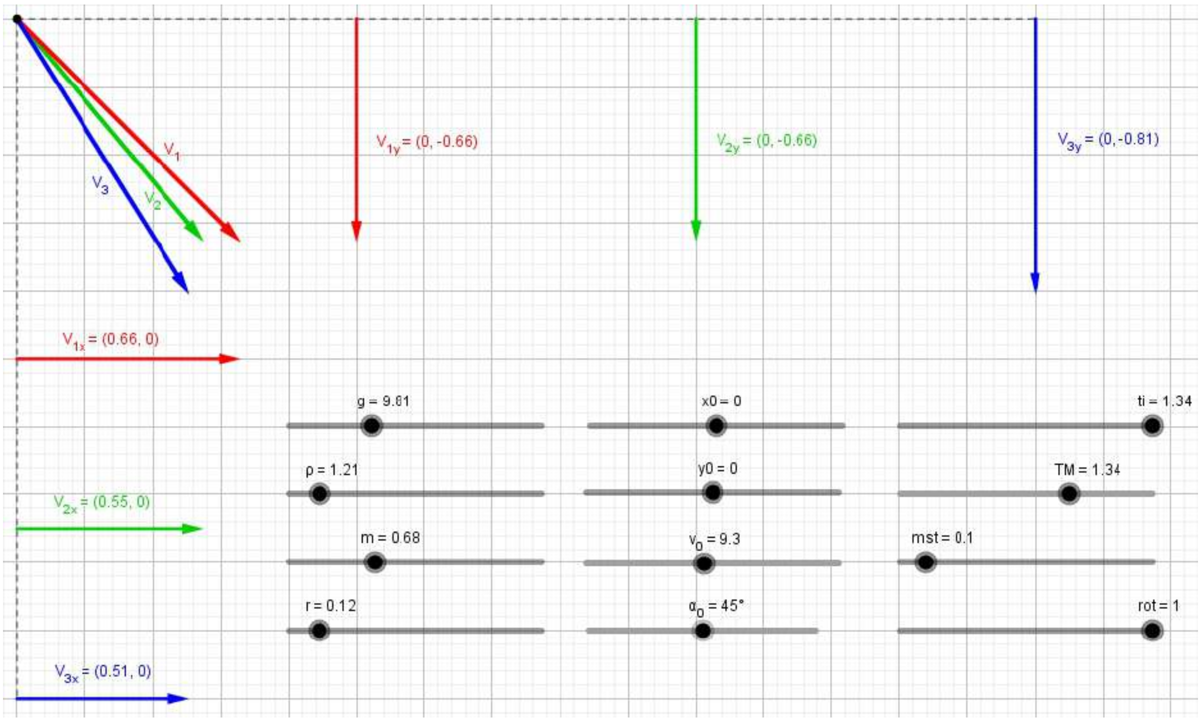

Figure 9: The dynamic vector diagram of velocities of bodies plotted in GeoGebra for MM I – MM III+ (clockwise rotation) at the end of motion: `ti=1.34`, `rot=+1`.

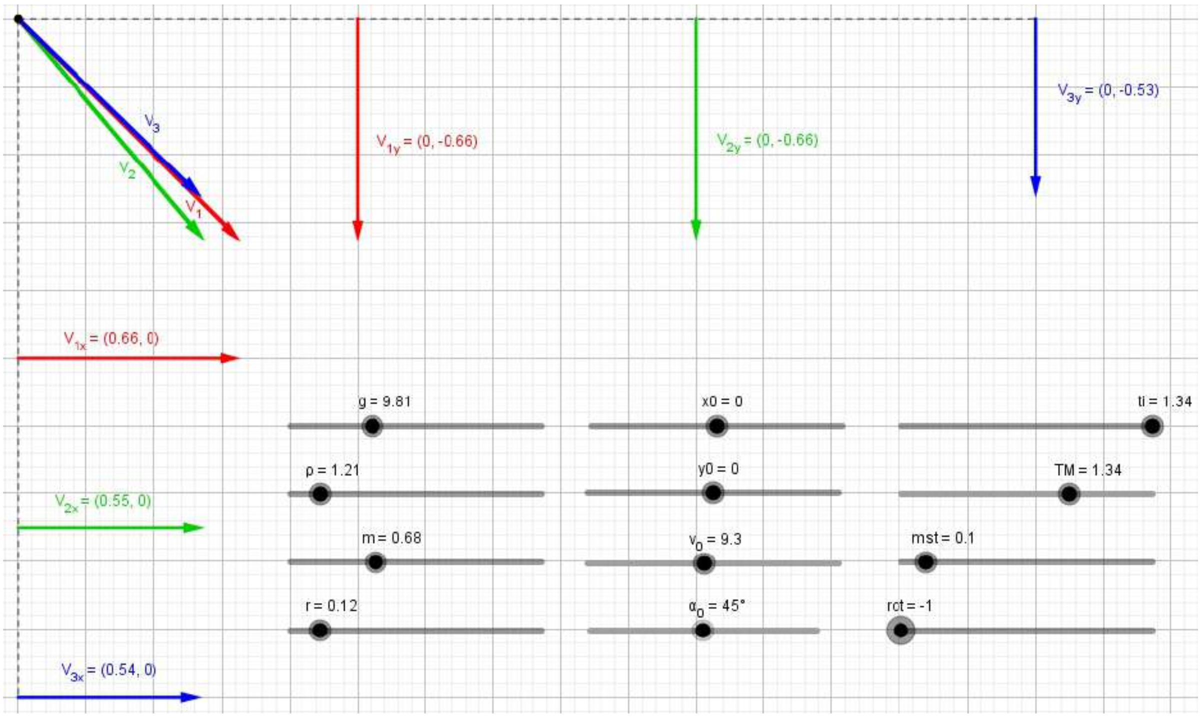

Figure 10: The dynamic vector diagram of velocities of bodies plotted in GeoGebra for MM I – MM III- (counterclockwise rotation) at the end of motion: `ti=1.34`, `rot=-1`.

representation not only of the absolute value of the body's velocity and its projections (this can be judged by the length of the corresponding vectors) but also of the direction of motion of the body (this can be seen directly in the direction of the vector of body velocity).

Figure 11 allow us to compare the plots of the horizontal projections of velocity of the body `vx1(t)`, `vx2(t)`, `vx3(t)` for the three different models MM I, MM II and MM III for two cases: when `rot=+1` (clockwise rotation) and `rot=-1` (counterclockwise rotation). Studying these plots provides for the students a lot of useful information about the features of body movement thrown at an angle to the horizon under different conditions. In particular, these plots are shows clearly that when rotated clockwise the body at the beginning of the movement accelerates in the horizontal direction and then slows down. On the contrary, for `rot=-1` the body slows down at first, but somewhat accelerates at the end of the movement.

The GeoGebra allows us to build similar plots and diagrams for all functions that are the solution of the models. Performing their interactive comparisons at various values of the parameters of the models we can quickly conduct a mini-study to establish the all necessary facts or identify the patterns. For example, the Fig. 12 shows the plots of the functions `y1(t)`, `y2(t)`, `y3(t)` for the MM I, MM II, MM III when `rot=1` and `rot=-1`. Changing the time of simulation TM we can quickly set the time point when the body touches the surface of the earth (determine the flight time). As you see, for identical input parameters of the model, the body rotating clockwise will fall to the surface of the earth in 1.14 s and the body rotating counterclockwise will be flying 1.46 s. This technique ensures the effective formation of research competencies of the students.

Similarly, our students study and analyze the forces acting on the body during movement and their resultants, as well as their projections. Performing computer simulations in Excel and GeoGebra based on the created mathematical models they observe and analyze, for example, how these vector quantities change at different points in time, what are the tendencies of these changes, what they mean and what they indicate. The corresponding illustrations using GeoGebra will be given below. This approach contributes to formation of the analytical abilities and development of skills of graphic analysis of students.

2.5 Performing the Learning Exercises with Excel and GeoGebra (Group EG)

The experimental group EG performed the same learning exercises using simultaneously Excel and GeoGebra in accordance with methodology described above.

The participants of this group used Excel (if feel it necessary or expedient, in particular, for numerical calculations or for presenting the results in tabular form) or the GeoGebra software for visual representation and analysis the dynamic characteristics in form of plots and dynamic vector diagrams. As example of these works you may see the vector diagrams of the forces acting on the body plotting according to the models M I, MM II and MM III in figure 13 and figure 14.

3 RESULTS

The table 1 shows the results of final learning outcomes of students of the Faculty of Engineering and Technology of the agricultural university at the end of the experiment described in this article: training the basics of mathematical modeling using visualization of the dynamic characteristics of mechanical movement in the form of dynamic vector diagrams. The final learning outcomes of the students of groups E, G and EG were evaluated on the results of solving a set of typical learning problems or individual independent works. These results are presented here on a 100-point scale (Flehantov and Ovsiienko, 2019).

The primary statistical data processing results of the experiment (table 2) are showed that the average scores in all groups (mean) are different. The means for groups E and G close to each other (73.36 and 73.85) but both lower than the mean of group EG (78.25). The mean values in groups E and G almost coincide with similar indicators in the same groups of the previous years: MeanE=73.36 (2019) vs. 73.4 (2018); MeanG=73.85 (2019) vs. 73.7 (2018). At the same time the mean value in group EG-2019 exceed the corresponding figure in group EG-2018: MeanEG=78.25 (2019) vs. 77.4 (2018). The result of Shapiro-Wilk test shows the trust of hypothesis about normal data distribution in all groups.

Analysis of variance (ANOVA) showed a statistically significant difference in average values of learning outcomes (Score/Point/Bal) in all groups ($F = 4.678693$; $p = 0.010613$) (table 3). The post-hoc comparison for means of groups E vs. G, E vs. EG, G vs. EG shows that the difference between the means of groups E and G is within the statistical error (table 4). The pair-wise post-hoc comparisons results indicate the statistical significance of the difference between the mean for group EG and the mean groups E and G.

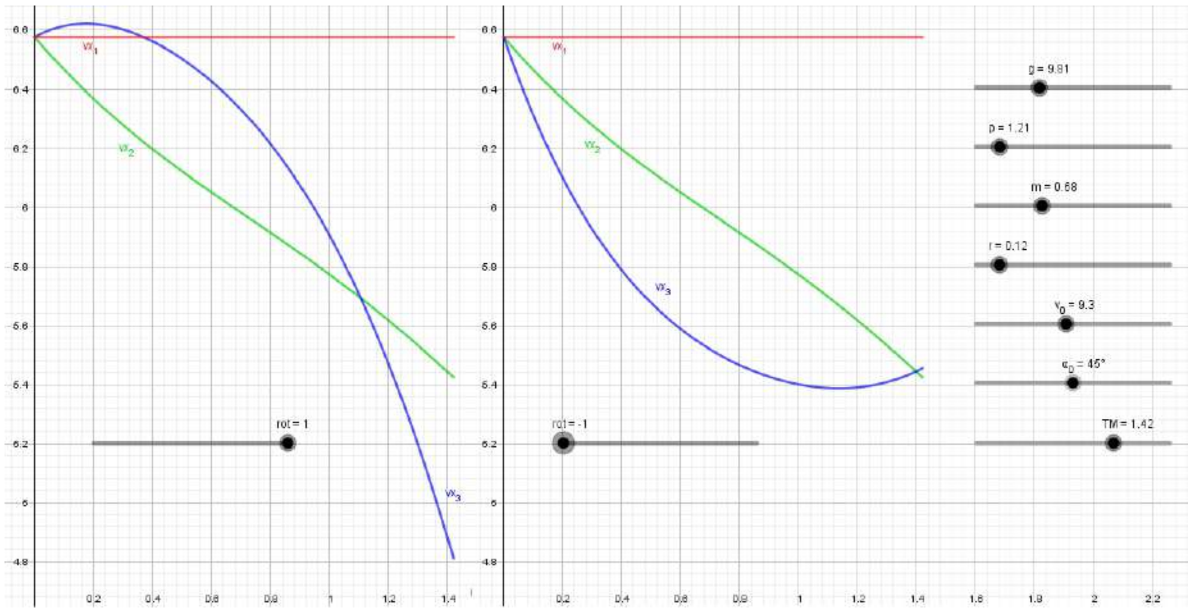

Figure 11: The visual study in GeoGebra: how changes the projection v_x for math models MM I, MM II, MM III+ ($rot = +1$, clockwise rotation) and MM III- (`rot=-1`, counterclockwise rotation).

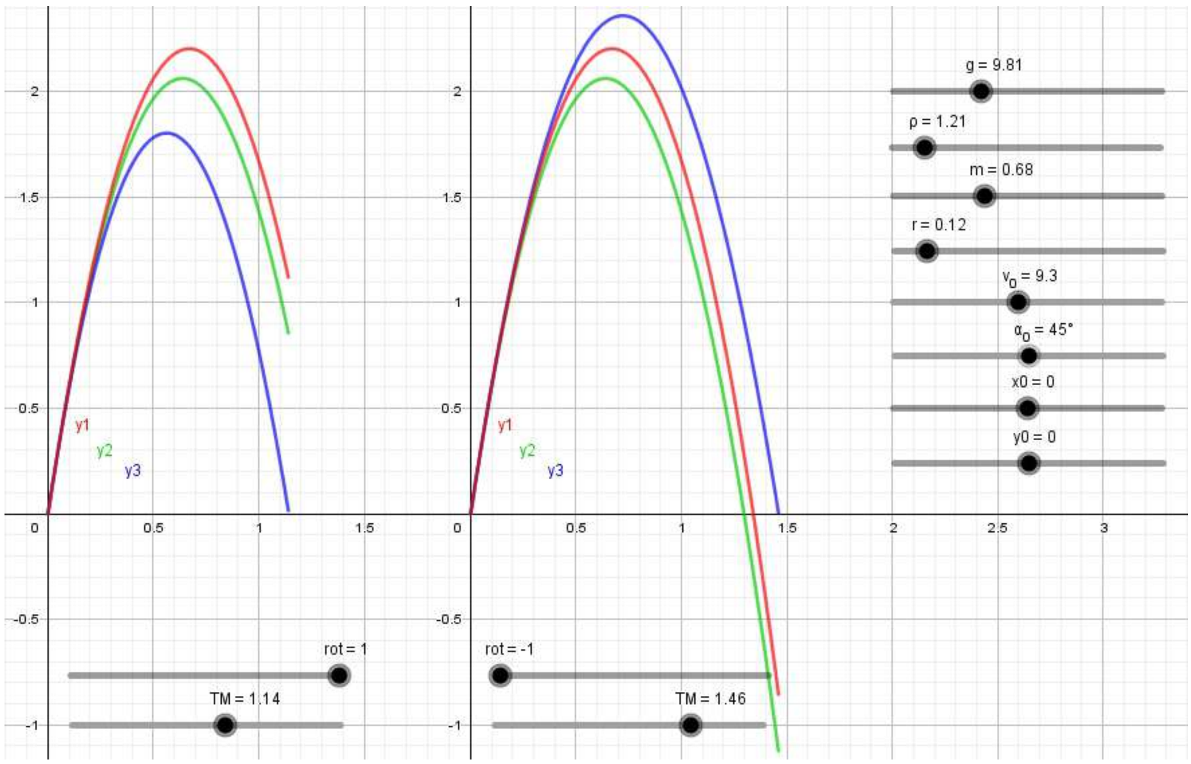

Figure 12: The visual study in GeoGebra: how long is the spherical body flight in air according to different math models if the body rotate clockwise and counterclockwise? (`rot=+1` and `rot=-1`).

4 DISCUSSION

In this article we made compare the earlier results we obtained when our students at first used Excel spreadsheets as the tool for solving learning exercises and then the GeoGebra dynamic geometry system was added. At the same time during the training sessions

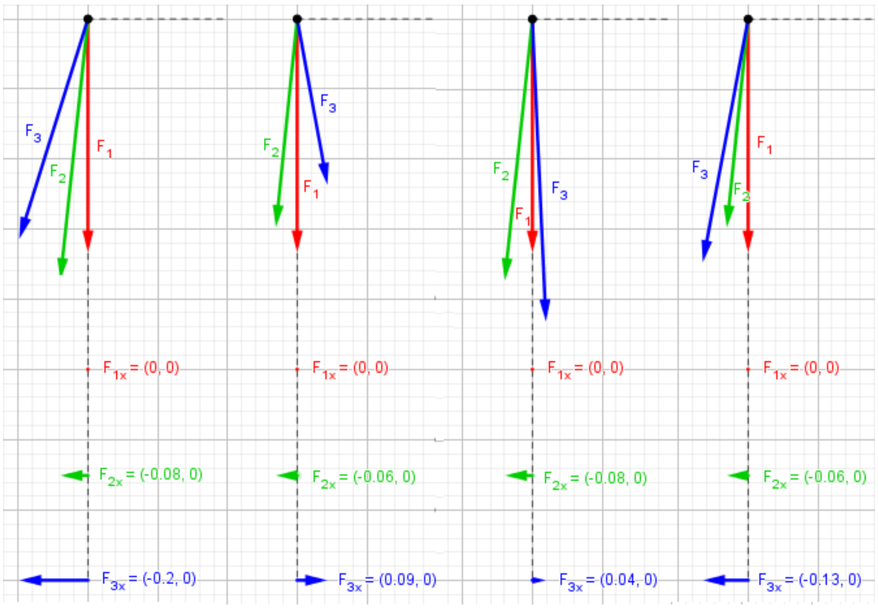

Figure 13: The dynamic vector diagram of X-component F_x of the resultant of the forces acting on the body in the four cases of flight: `ti = 0, rot = 1`; `ti = TM, rot = 1`; `ti = 0, rot = -1`; `ti = TM, rot = -1`.

Table 1: Final learning outcomes of students after the experiment.

Score	**50-55**	**55-60**	**60-65**	**65-70**	**70-75**	**75-80**	**80-85**	**85-90**	**90-95**
Group E	1	2	6	9	14	10	7	4	-
Group G	-	3	6	10	13	15	8	3	1
Group EG	-	1	3	5	10	15	9	7	5

Table 2: Primary statistical data processing results.

Group	**Valid N**	**Mean**	**Conf.-95%**	**Conf.+95%**	**Median**	**Mode**
E	53	73.36	71.16	75.55	74	Multiple
G	59	73.85	71.74	75.95	74	76
EG	55	78.25	75.94	80.57	77	76

Group	**Freq. Mode**	**Min**	**Max**	**SD**	**Shapiro-Wilk**	**test**
E	5	55	90	7.96	W=0.98823	p=0.87840
G	5	56	91	8.08	W=0.98749	p=0.80486
EG	6	60	95	8.56	W=0.98158	p=0.55809

Table 3: ANOVA results.

	SS	**df**	**MS**	**SS_Err**	**df_Err**	**MS_Err**	**F**	**p**
Point	1249.818	2	624.9091	10588.73	164	64.56544	4.678693	0.010613

we consistently and systematically studied how various methods and techniques of visualizing the results of modeling affect the results of educational achievements of students who study at the agrarian university (the specifics of teaching this group of students to mathematical disciplines were discussed by us earlier).

Based on the above we conclude that visualization of the dynamic characteristics of mechanical movement in the form of dynamic vector diagrams using the GeoGebra software allow to improve the educational achievements of students of the agrarian university when studying the basics of mathematical modeling.

There are several possible reasons for this result. At first, since implementation of mathematical models in MS Excel, in fact, is a stepwise reproduction of the sequence of the mathematical operations by means of spreadsheets, than their use contributes to a better understanding of the students of the technical

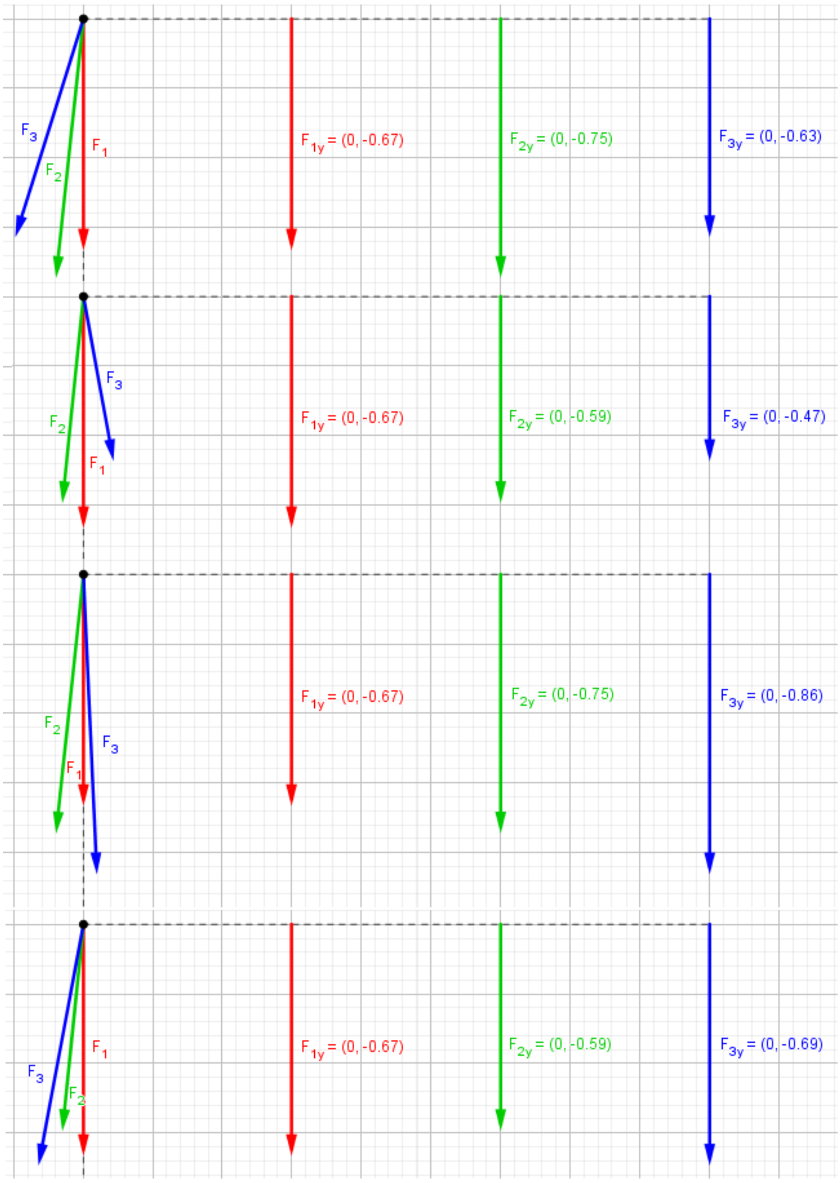

Figure 14: The dynamic vector diagram of Y-component F_y of the resultant of the forces acting on the body in four cases (from top to right): `ti = 0`, `rot = 1`; `ti = TM`, `rot = 1`; `ti = 0`, `rot = -1`; `ti = TM`, `rot = -1`.

component of mathematical modeling, provides them with the opportunity to diagnose calculations by itself, and also creates additional didactic benefits for the teacher, such as being able to identify and discuss with students all the intermediate effects and simulation outcomes that may remain invisible (hidden) when using professional computer math systems such as Mathcad (Flehantov and Antonets, 2017), Mathematica, MATLAB or Maple, etc.

In addition, visualization of the trajectory of mechanical motion of bodies in the form of Excel charts provides the formation of intuitive ideas about how the characteristics of movement of bodies changes depending on the initial conditions and other parameters. This allows to students to acquire the skills of consciously adjusting input parameters to achieve the desired simulation result. However the standard Excel features do not allow them to visualize the changes in the instantaneous velocities and the direction of motion of bodies along their trajectories. Therefore using of Excel in training does not create sufficient conditions for the formation of skills to analyze the dynamic characteristics of movement based on numerical data.

Table 4: Pair-wise post-hoc comparisons results.

Pair-wise post-hoc comparisons of means	E vs. G	E vs. EG	G vs. EG
LSD-test	p>0.9468	p<0.0262	p<0.0120
Duncan-test	p>0.9475	p<0.0135	p<0.0151
Tukey HSD for unequal N test	p>0.9977	p<0.0061	0.0048

On the other hand the GeoGebra allows to the students to form their intuitive spatial perceptions faster by visual analyzing dynamic motion characteristics. In our view this is made possible primarily by the dynamic visualization of vector characteristics of motion. We observed that after completing the proposed learning exercises with the help of GeoGebra the students more easy formulated the meaningful answers to questions of qualitative evaluation. Studying the dynamic plots such as figure 11 in an interactive mode allows them quickly and accurately answer the questions such as: "How does the change the direction of rotation will affect the linear velocity of the body?", "At what points in time the velocity of the body will in airless space be equal to the speed of the body in air?" and so on. However, the students who were working in Excel environment were better at answering questions about the quantitative characteristics of the models.

That's why as in our previous study (Flehantov and Ovsiienko, 2019, 2016) we are of the opinion that using only GeoGebra to study the basics of modeling creates the inconvenience to evaluate the simulation results in a numerical dimension. Therefore it does not provide a sufficient level of skills to numerically evaluate the characteristics of the phenomenon or the simulated process. At the same time the wide using of GeoGebra during BMM training contributes to the effectively formation of intuitive spatial representations that are very important for engineering professionals. Because, as in the previous study, there is no significant difference between final learning outcomes in groups E and G, this could mean that simultaneous use of Excel and GeoGebra compensates for these shortcomings and therefore provides the best educational achievements. At the same time, the using of dynamic vector diagrams in GeoGebra environment to learning the basics of mathematical modeling further up these results.

5 CONCLUSION

The analysis of the data we collected shows that the students who simultaneously used GeoGebra and Excel at the highest level of learning difficulty in dynamic vector diagram visualization mode demonstrated a better understanding of mathematical modeling problems and improved their ability to use mathematical modeling to solve problems. At the same time, we found no statistically significant difference in learning outcomes between groups of students who used only Excel or only GeoGebra separately during BMM training. In addition, we noticed that students who used Excel for computer modeling responded better to quantitative questions of exam. The students who performed their learning exercises exclusively in the GeoGebra environment were much better at dealing with quality questions.

Results of this study we get conclusion that the simultaneous use of Excel and GeoGebra with vizualisation mode by dynamic vector diagrams demonstrated improved the academic achievement of students with BMM. This is indicated by the statistically significant difference between the average results of students' academic achievement, shown in table 2 confirmed with the results of table 3 and table 4.

So, this research show that the proper use of appropriate software to visualize the dynamic characteristics of mathematical models in the context of the teaching BMM at an agrarian university is an effective way to improve student performance. We were concluded that the hypothesis that visualization of the characteristics of mechanical movement by the dynamic vector diagrams can to improve the educational achievements of students is true. However the assumption that visualizing the results of modeling using GeoGebra in conjunction with a differentiated approach to learning creates additional conditions for improving students' knowledge, taking into account the specifics of their vocational training requires further verification.

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Professional Training of Bachelors in Information Technologies based on Education for Sustainable Development Principles

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Keywords: Bachelors in Information Technologies, Education for Sustainable Development, Professional Training, Experimental Research.

Abstract: The article examines the professional training of future bachelors in Information Technologies (IT) at universities in the context of the implementation of the Sustainable Development Goals set by the UN General Assembly, as well as the Education for Sustainable Development (ESD) principles. The UNESCO documents on education for sustainable development, scientific sources on the professional training of future IT specialists, as well as the integration of sustainable development into relevant educational programs are analyzed. The methodology and results of experimental work carried out intending to overcome existing contradictions, promoting sustainable development of information technology education and implementation of ESD principles in the process of professional training of future bachelors in IT are presented. In particular, the organizational and methodological conditions, that were implemented into the educational process, and experimental data are presented. The effectiveness of the experimental work was proved by statistical verification of the reliability of the obtained data.

1 INTRODUCTION

The achievement of the Sustainable Development Goals set in 2015 by the UN General Assembly (General Assembly, 2015) is linked to the training of highly qualified professionals from all sectors of the economy who are capable of reflection, professional mobility and lifelong learning, aware of the responsibility for the results of their activities. Such training is based on Education for Sustainable Development (ESD) principles.

According to UNESCO Roadmap "ESD empowers learners to take informed decisions and responsible actions for environmental integrity, economic viability and a just society, for present and future generations, while respecting cultural diversity. It is about lifelong learning, and is an integral part of quality education. ESD is holistic and transformational education which addresses learning content and outcomes, pedagogy and the learning environment. It achieves its purpose by transforming society" (UNESCO, 2014, p. 12).

Intensive development of information technology and the need to overcome the numerous challenges facing humanity, lead to an increase in requirements for professionals whose activities are creation, implementation and maintenance of software. The professional training of such specialists in the bachelor's and master's degrees in Ukraine is carried out in the specialities of the field of knowledge "Information Technology". To ensure that the level of professionalism of graduates of these specialities corresponds to the requirements of society, effective procedures of updating the content, forms, methods and means of training should be implemented based on systematic monitoring of the state of the industry and a balanced combination of fundamental, applied and humanitarian components of higher education.

An important area of professional work of IT specialists is the software development using an object-

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oriented approach, so graduates of higher education institutions should understand its fundamental principles, be able to use object-oriented programming (OOP) languages, to apply existing and make their own decisions, to decompose and compose tasks, to document the process of building an object model, etc. The lack of the necessary capabilities of the developers is one of the reasons for the low quality of software products, which in some cases pose a threat to the sustainable future. Other threats include a focus on current tasks and immediate goals, lack of understanding of global economic, environmental and social issues, opportunities to overcome or minimize them at the level of individual IT professionals or businesses, the impact of IT products on the present and future, and responsibility to future generations.

Scientists have thoroughly developed conceptual foundations and examined some aspects of higher education and professional training of future software engineers. However, insufficient attention is paid to developing their professional competence in the study of object-oriented programming, as well as to acquire the knowledge and skills necessary to pursue activities with a view to sustainable development goals. Therefore, there are contradictions between the need to combine the fundamental theoretical and thorough practical training of future software engineers as highly qualified specialists and the limited time of studying the disciplines of the vocational training cycle; the necessity of using abstraction, decomposition and composition in the process of studying OOP and insufficient level of abstract-logical thinking in students; high level of complexity of OOP educational content and insufficient readiness of higher education students to systematic cognitive self-activity; possibility to demonstrate the object-oriented approach on the example of large projects and traditional use of educational tasks with limited content; the society requirements for the professional training of software engineers and the students' lack of awareness of these requirements; lack of knowledge on sustainability issues and the need to promote a sustainable future in professional life and daily life (Koniukhov, 2019).

The other important issue is the formation of professional competencies of bachelors in Information Technologies in the conditions of a shortened cycle of professional training at universities. The contradictions that hinder the efficient formation of professional competences of future software engineers in the shortened cycle of training at universities have been identified, namely: between the requirements for the level of training of software engineers and insufficient motivation of higher education students to study and improve their skills; between the educational needs of higher education students and the limited ability to build individual educational trajectories and a combination of different forms of education, including non-formal one, at universities; between the availability of higher education students with professional competences formed during the previous level of education, and the content of educational programs for shortened cycle training of future software engineers at the bachelor's level at universities; between the need to comply with the provisions of the standards of higher education in Ukraine at the bachelor's level and the limited period of study in the educational programs for shortened cycle training of future software engineers at the bachelor's level at universities (Krasheninnik, 2020).

Therefore, there is a need to create at higher education institutions the conditions for students to develop appropriate professional competencies.

Purpose of the article: to present the results of experimental work carried out to overcome the mentioned contradictions and to promote sustainable development of IT education and implementation of ESD principles in the process of professional training of bachelors in Information Technologies.

2 LITERATURE REVIEW

As Mulà et al. (Mulà et al., 2017, p. 798) emphasis "The world is shaped by an education system that reinforces unsustainable thinking and practice". So, it is very important to transform an education system taking into account the aims of sustainability and sustainable future. Education for sustainable development principles is substantiated in numerous UNESCO documents (UNESCO, 2014, 2009, 2016; Tilbury and Mulà, 2009) and discussed in (Dlouhá et al., 2017; Lobanova et al., 2020; Mulà et al., 2017; Vlasenko et al., 2021).

Internationally recognized ESD principles are named by Tilbury and Mulà (Tilbury and Mulà, 2009). They are the next: Futures thinking; Critical and creative thinking; Participation and participatory learning; Partnerships; Systemic thinking (Tilbury and Mulà, 2009, p. 5). Moreover, there are pointed out key ESD learning themes (eg.: Gender equality; Biological diversity; Ecological principles, ecosystems; Natural resources management; Health and well-being; Consumerism and ethical trade; Rural and urban development; Corporate social responsibility) that are critically significant to the sustainable development agenda (Tilbury and Mulà, 2009, p. 6).

Providing quality education as one of the goals of sustainable development is an important area of modern pedagogical research. In particular, in 2020 the International Conference on Sustainable Futures: Environmental, Technological, Social and Economic Matters (ICSF 2020) was held, during which a workshop on sustainable education was held (Semerikov et al., 2020).

In particular, interesting results are presented in publications (Lavrov et al., 2020; Hevko et al., 2020; Glazunova et al., 2020), which consider ways to implement the problems of sustainable development in IT education.

Implementation of ESD principles in the process of professional training of bachelors in Information Technologies is in different ways, in particular: deep informatization of the educational process (Fedorenko et al., 2019); enhancing opportunities for professional mobility and lifelong learning for IT professionals through the development and implementation of intelligent means of recognition of qualifications and competencies obtained in different countries and educational institutions (Osadchyi et al., 2017); improving educational programs for the short cycle of vocational training (Osadchyi and Krasheninnik, 2017; Krasheninnik, 2020); improving the content, forms, methods and tools of object-oriented programming learning (Koniukhov, 2019; Koniukhov and Osadcha, 2020); introduction of sustainability issues to the content of educational programs (Penzenstadler and Fleischmann, 2011; Fisher et al., 2016; Cai, 2010; Hilty and Huber, 2018) and others.

Researchers in the field of professional training IT specialists note that sustainable development issues are hardly addressed in relevant university education programs. However, software developers should take their share of responsibility for sustainability because of the growth of IT's productivity in combination with cutting down of life cycles and growing resource problems of our planet (Penzenstadler and Fleischmann, 2011, p. 454). In this regard, it is necessary to determine the mechanisms for introducing sustainable development issues into university bachelors in Information Technologies curricula, as well as motivating students and teachers to address them.

Penzenstadler and Fleischmann (Penzenstadler and Fleischmann, 2011) offer a strategy for integrating the concept of sustainability into a degree course scheme across three stages: 1) to propose a seminar and form a core of interested people; 2) to give a lecture series for broadening the awareness for sustainability; 3) to establish sustainability as a topic by integrating it into the syllabus of appropriate software engineering lectures with teach-the-teacher seminars. During a seminar, students should examine chosen issue and present their topic in class. They are offered such seminar topics as "Climate killer Internet? Energy-efficient nets and systems have a notable impact", "Climate change research and software engineering for climate research", "Marketing for sustainability — how can I make it matter for software engineers?" etc. (Penzenstadler and Fleischmann, 2011, p. 455-456).

Fisher et al. (Fisher et al., 2016) emphasize the nexus between sustainability and computer science and the necessity to integrate sustainability science and engineering into computing education (Fisher et al., 2016, p. 95). They consider two levels of integration of sustainability into computer science higher education (the course level and the course component level) and give different examples of such combination. Scientists identify the course-level integration as introducing computer science courses that focus on topics at the intersection of computing and sustainability. These are such courses as "Computing, Energy, and the Environment", "Seminar on Computational Sustainability: Algorithms for Ecology and Conservation" etc. Component-level integration is implemented by introducing lectures, exercises, and projects, with sustainability themes into computer science courses that do not have a sustainability focus, such as courses in computer organization, databases, and artificial intelligence (Fisher et al., 2016, p. 93-94).

Three sustainability integration strategies are offered by Cai (Cai, 2010): 1) developing a new course named "green computing" covering selected sustainability and green computing topics; 2) designing and developing independent green computing learning modules and projects that can be easily plugged into the existing computer courses; 3) an integrative and transformative approach to completely re-design some computing courses with sustainability as one of the top priorities (Cai, 2010, p. 525-526).

Hilty and Huber (Hilty and Huber, 2018) consider that sustainable development is an important part of the curriculum of ICT-related study programs and content is strongly significant to interest students in it. They present results of an empirical investigation to identify topics with the greatest potential to motivate students on sustainability. Researchers reveal five clusters of such topics, namely: "ICT impacts on sustainability"; "Material resources for ICT hardware: Informal recycling"; "ICT as an enabler: Saving material and energy: Videoconferencing example"; "Resource consumption: Global distribution"; "Rebound effect: General concept" (Hilty and Huber, 2018, p. 652).

An example of IT students' participation in a project aimed solution one of sustainability tasks –

"provide safe, non violent, inclusive and effective learning environments for all" (General Assembly, 2015) – is given in (Kompaniets et al., 2019).

3 RESEARCH METHODOLOGY

3.1 Research Statement

The ideas of education for sustainable development were implemented in the process of research and experimental work on forming the professional competence of bachelors in Information Technologies.

The study consisted of two stages and covered 2015–2019. The main stage involved the professional training bachelors in the field of Information Technologies by the way of learning object-oriented programming. An additional stage was aimed formation of professional competencies of future IT specialists in the conditions of a shortened cycle.

The difference between the main and additional stages was the next:

1. The main stage was attended by students who studied in the terms of the standard period of study (4 years).
2. The additional stage was attended by students who studied for a reduced period of study (2 years). Most of them already had a professional education in the field of information technology at the level of a junior specialist.

We followed this sequence of pedagogical research:

1) comparison of the initial state of students' professional competence in the control and experimental groups according to certain criteria and indicators, establishing the absence of statistically significant differences;
2) introduction of the developed organizational and methodological conditions for the formation of professional competence of future IT specialists in the learning process in the experimental group;
3) comparison of the final state of students' professional competence in the control and experimental groups according to certain criteria and indicators, establishing the presence of statistically significant differences (Novikov, 2004, p. 10).

3.2 Main Stage Methodology

The main stage experiment was conducted during 2015–2018 at Ukrainian universities, in particular, Bogdan Khmelnytsky Melitopol State Pedagogical University. 135 computer science students have taken part in the qualifying and forming stages of the pedagogical experiment. The number of the control group (CG) was 69 people, experimental (EG) – 66 people.

In the course of this work, the levels of bachelors' professional competence components identified in (Koniukhov, 2019) were diagnosed:

- motivational: a set of motives that encourage higher education students to actively study OOP; their interest in the in-depth study and use of OOP in their further professional activities; readiness for self-development in object-oriented development;
- cognitive: development of abstract-logical thinking; possession of techniques of formalization, abstraction, decomposition and composition; understanding the fundamental basics of OOP and their implementation in different programming languages; set of theoretical knowledge of fundamental concepts and applied aspects of OOP;
- operational: skills in object-oriented programming necessary for effective professional activity;
- reflexive: the ability to self-understand, analyze and evaluate yourself as a specialist and your actions in the current situation, in the past and the future, as well as yourself as a member of the software development team.

Since the ECTS scale is used in the institutions of higher education of Ukraine to evaluate students' academic achievement, five levels of formation of these components of the professional competence of bachelors in Information Technologies have been identified:

- professional: certifies the formation of a component of professional competence at the level of an experienced software developer and the ability of the student to enter professional activity as a mid-level specialist without additional training, corresponds to the level "A" of the ECTS scale;
- high: certifies the formation of a component of professional competence at the level of a junior software developer and the ability of the student to start professional activity and independent tasks without additional training, corresponds to the level "B" of the ECTS scale;
- sufficient: certifies the formation of a component of professional competence at the level of the junior software developer and the ability of the student to start professional activity and independently perform tasks with additional training at the enterprise, corresponds to the level "C" of the ECTS scale;

- low: certifies the formation of a component of professional competence at the level of the novice programmer and the ability of the student to begin professional activity as a junior software developer only under the direct supervision and with additional training at the enterprise, corresponds to the level “D” of the ECTS scale;
- critical: certifies the extremely low level of professional competence component and the student’s lack of ability to take up professional work as a software developer, corresponds to the “E” level of the ECTS scale.

In the experimental group, the educational process was organized based on the following organizational and methodological conditions (Koniukhov, 2019):

1. Formation of positive motivation for students to study and apply in future professional activities of OOP. The implementation of this condition included a demonstration of examples of software development practice, meetings with leading specialists of IT enterprises, organization of group implementation of software projects, involvement of students in the discussion of practical aspects of the software engineering.
2. Formation of a cross-cutting content-activity line of studying OOP within the disciplines of the vocational training cycle. Within each successive course, fundamental concepts of object-oriented programming were repeated, and they were considered at a new level of complexity, taking into account the specifics of a particular area of software development.
3. Application of appropriate forms and methods of formation in higher professional qualifications. The implementation of this condition involved the implementation of various types of software projects, the use of training tasks in object-oriented programming, interactive teaching methods and game technologies.
4. Use of modern information and communication technologies in the process of education of students of OOP, namely: software for educational purposes, software development environments, visualization tools, training management systems, distance courses in academic disciplines and additional specialized online resources.

Some ESD ideas were implemented during the development of the students’ program projects. In particular, they were offered project topics such as developing programs for the statistical processing of observation data (demographic economic, meteorological, medical, biological, etc.); development of educational programs for students of general secondary education institutions (simulators, didactic games, etc.); development of programs for automation of separate production processes for enterprises of different industries, etc. To create quality software, students had to pre-analyze the problem given the problems of a sustainable future and the goals of sustainable development.

The measures envisaged by the pilot program were implemented within the training disciplines of the cycle of professional training: “Programming”, “Object-oriented programming”, “Cross-platform programming”, “Web application programming and support”.

To evaluate the likelihood of the experimental data obtained, a method of testing statistical hypotheses was used.

The hypothesis of the absence of significant differences in the average values of indicators of the formation of components of students’ professional competence in control and experimental groups was tested with Student’s t-test.

Volumes of control and experimental groups $n_{CG} = 69$ and $n_{EG} = 66$ respectively. Number of degrees of freedom $k = 133$. Critical significance of the Student test for 133 degrees of freedom and significance level $\alpha = 0.05$: $t_{cr} \approx 1.98$.

3.3 Additional Stage Methodology

The additional stage experiment was conducted during 2016–2019 at Ukrainian universities, in particular, Bogdan Khmelnitsky Melitopol State Pedagogical University. The research and experimental work involved examining problems and contradictions, identifying ways of overcoming them, implementing organizational and pedagogical conditions for the formation of professional competencies of future software developers in the shortened cycle of training, checking the effectiveness of the measures taken. A pedagogical experiment has been consisted of qualifying and forming stages. It was carried out at various stages among 405 Information Technologies students of the bachelor grade majoring in 121 Software Engineering, 122 Computer Science, 123 Computer Engineering, who studied based on the shortened training cycle. The control group included 207 students; the experimental group consisted of 198 students.

In the course of this work, the levels of professional competence components of future software developers identified in (Krasheninnik, 2020) were diagnosed:

- motivational: internal motivation for professional activity in the speciality of software developer, continuing education and training; at the stage of the pedagogical experiment the analysis was carried out separately by the criterion of internal motivation to continue education and advanced training and by the criterion of internal motivation to professional activity like a software developer;

- cognitive: complete acquisition of knowledge and understanding of the disciplines of the training cycle, the ability to formulate judgments based on available information and cognitive skills;
- operational: the ability to practical application of knowledge and skills in the professional activity, as well as to the effective organization of this activity;
- communicative: abilities for effective oral and written communication in groups with different composition of participants and goals of joint activities;
- reflexive: the ability to reflect on educational and production activities.

Five levels of formation of these components of the professional competence have been identified:

- high: the component is formed to a sufficient extent for the implementation of conscious educational and self-educational activities, as well as independent solution of professional problems in the field of software development on the middle level; corresponds to level "A" of academic achievements by the ECTS scale;
- sufficient: the component is formed to a sufficient extent for the implementation of conscious educational and self-educational activities, as well as independent (or with little help) performance of professional tasks as a junior software developer; corresponds to the level "B" of academic achievements by the ECTS scale;
- medium: the component is formed to a sufficient extent for the implementation of educational and self-educational activities, as well as the implementation of production tasks in the process of professional activity as a junior software engineer under management and with the help of experienced professionals; corresponds to the level "C" of academic achievements by the ECTS scale;
- critical: the component is formed at a level sufficient to perform certain types of educational activities and production tasks in the process of professional activity as a junior software engineer under the direct guidance and control of teachers or experienced professionals; corresponds to level "D" of academic achievements according to the ECTS scale;
- low: the component is formed at a level insufficient for effective educational and professional activities in the speciality of software engineer; corresponds to the level "E" (satisfactory success) or "F" / "FX" (unsatisfactory success) of academic achievements on the ECTS scale.

In the experimental group, the educational process was organized based on the following organizational and methodological conditions (Krasheninnik, 2020):

- formation of stable positive internal motivation to higher education, professional activity, advanced training;
- systematic review and updating of educational programs for shortened cycle training of future software developers at the bachelor's level, taking into account current trends in the field of information technology and higher education;
- providing future software developers opportunities for individual educational trajectories under the conditions of the shortened cycle of professional training at universities;
- application of expedient forms, methods and means of formation of professional competencies of future software developers under the conditions of the shortened cycle of professional training at universities.

The probability of the results obtained at the qualifying and formative stages of the experiment has been checked using the Fisher test in combination with the Kolmogorov-Smirnov test.

4 RESEARCH RESULTS

4.1 Qualifying Stage

The empirical data obtained at the qualifying stage of the pedagogical experiment gave reason to draw the following main conclusions:

1) students in the control and experimental groups found an insufficient level of professional competence development: approximately one-third to two-thirds of them demonstrated low or critical level of professional competence;
2) the initial level of professional competence in both groups practically did not differ (the difference between the percentage of students at each level of education in terms of individual competence components did not exceed 3%), which testified to their homogeneity.

According to the results of estimation of the motivational component of professional competence, 34.78% of students (24 persons) of CG and 34.85% of students (23 persons) of EG revealed low or critical level. At the same time, 46.38% of students (32 persons) of CG and 45.45% of students (30 persons) of EG showed sufficient level. So, at the end of their first year, they understood the need for knowledge of object-oriented programming technologies and languages and were partially motivated to further study OOP.

According to the results of the assessment of the cognitive component of professional competence, 68.12% of students (47 persons) of CG and 68.18% of students (45 persons) of EG have found low or critical level. This situation is to a certain extent because the first year focuses on the study of algorithmization, structural and procedural programming, and the mechanisms of OOP are mostly considered indirectly to the extent necessary for writing programs in development environments.

According to the results of estimation of the operational component of professional competence, 75.36% of students (52 persons) of CG and 71.21% of students (47 persons) of EG revealed low or critical level. The reason for this is that at the end of the first year students have initial experience writing programs with classes and objects, but they do not yet use the full-scale OOP mechanisms.

As a result of assessing the reflexive component of the professional competence, 47.83% of students (33 persons) of CG and 48.48% of students (32 persons) of EG revealed low or critical levels. At the same time, 37.68% of students (26 persons) of CG and 34.85% of students (23 persons) of EG showed sufficient level, which testified to the partial formation of the ability to evaluate themselves as a student, member of academic group and software development team, as well as the results of its activities.

Valuation of the obtained data. The hypothesis about the absence of statistically significant differences in the average values of indicators of the formation of the components of students' professional competence in the control and experimental groups was performed using the Student's t-test.

The null hypothesis: there is no statistically significant difference between the samples, the average values of the indicators of the professional competence components of the students of the control and experimental groups are equal.

Alternative hypothesis: there is a statistically significant difference between the samples. the average values of indicators of the formation of components of professional competence of students in the control and experimental groups differ significantly.

The results of testing these statistical hypotheses are given in table 1.

Table 1: Results of valuation of the obtained data (qualifying stage of the experiment).

Components of professional competence	t_{emp}	**Conclusion**
motivational	0.47	$t_{emp} < t_{cr}$
cognitive	0.33	$t_{emp} < t_{cr}$
operational	0.12	$t_{emp} < t_{cr}$
reflexive	0.01	$t_{emp} < t_{cr}$

Thus, it is proved that there is no statistically significant difference in the levels of the professional competence components between students of the control and experimental groups at the qualifying stage of the pedagogical experiment, that is, the samples are homogeneous.

Based on the analysis of empirical data of the qualifying stage of the pedagogical experiment, it was concluded that the level of the professional competence of future software engineers was generally low and critical.

To increase this level, the study of object-oriented programming had to be organized in such a way as to ensure the acquisition and completeness of students' acquisition of basic and special knowledge of OOP (cognitive component), the effective formation of their OOP skills and ability to use them to develop software projects (operational component), persistent high motivation to study OOP, its further use in professional activity, and self-improvement in this field (motivational component), formation of the ability to evaluate and responsible attitude to the results of their work and role in the team (reflexive component).

4.2 Forming Stage

The empirical data obtained during the formative stage of the pedagogical experiment gave reason to make the following generalizations:

1) the overall level of students' professional competence has increased: in both groups the increase in the number of students at the professional and high levels, as well as the increase in the average values of the indicators of the components of professional competence, but the changes in the experimental group were more significant;
2) the final levels of the components of students' professional competence in the experimental group exceeded the corresponding indicators in the control group.

Based on these data, a preliminary conclusion was made about the effectiveness of implementing the organizational and methodological conditions for forming the professional competence of bachelors in Information Technologies in the process of studying object-oriented programming.

The results of the assessment of the motivational component of professional competence revealed that in the experimental group the percentage of students with professional and high level was equal to 21.21% (14 people) and 42.42% (28 people) respectively. In the control group, there were minor changes and this indicator was 10.14% (7 persons) and 18.84% (13 persons), respectively. A significant difference was observed in the indicators characterizing the number of students with low and critical levels: 6.06% (4 persons) and 3.03% (2 persons) in EG; 15.94% (11 persons) and 5.80% (4 persons) in CG respectively (figure 1).

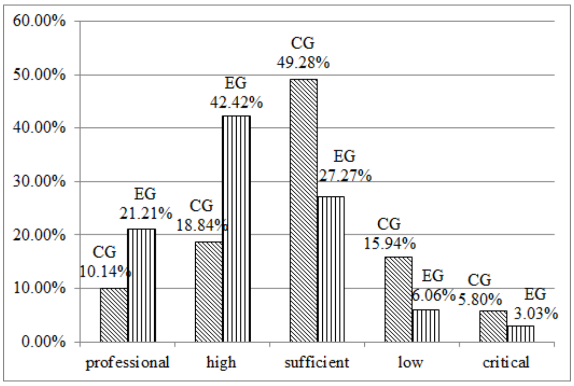

Figure 1: Formation of the motivational component of students' professional competence (forming stage of the experiment).

According to the results of the assessment of the cognitive component of students' professional competence, it was found that in the experimental group the percentage of students with professional and high level became equal to 21.21% (14 persons) and 36.36% (24 persons), respectively. In the control group, there were slight changes and this indicator was 4.35% (3 persons) and 11.59% (8 persons) respectively. A significant difference was observed in the indicators characterizing the number of students with low and critical levels: 9.09% (6 persons) and 3.03% (2 persons) in EG; 28.99% (20 people) and 8.70% (6 people) in CG (figure 2).

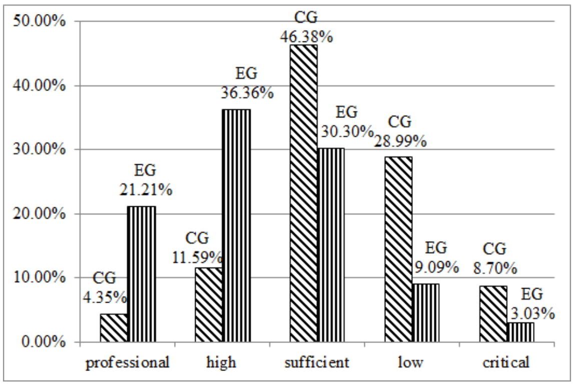

Figure 2: Formation of the cognitive component of students' professional competence (forming stage of the experiment).

According to the results of the evaluation of the operational component of students' professional competence, it was found that in the experimental group the percentage of students with professional and high level was equal to 19.70% (13 persons) and 40.91% (27 persons), respectively. In the control group, there were slight changes and this figure was 5.80% (4 persons) and 15.94% (11 persons), respectively. A significant difference was observed in the indicators characterizing the number of students with low and critical levels: 9.09% (6 persons) and 3.03% (2 persons) in EG; 31.88% (22 persons) and 13.04% (9 persons) in CG, respectively (figure 3).

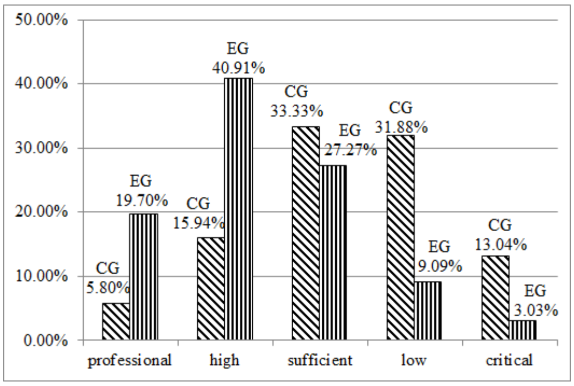

Figure 3: Formation of the operational component of students' professional competence (forming stage of the experiment).

According to the results of the evaluation of the reflexive component of students' professional competence, it was found that in the experimental group the percentage of students with professional and high level was equal to 22.73% (15 people) and 30.30% (20 people), respectively. In the control group, there were slight changes and this indicator was 10.14% (7 people) and 15.94% (11 people), respectively. A significant difference was observed in the indicators characterizing the number of students with low and critical levels: 6.06% (4 persons) and 3.03% (2 persons) in EG; 23.19% (16 people) and 8.70% (6 people) in CG, respectively (figure 4).

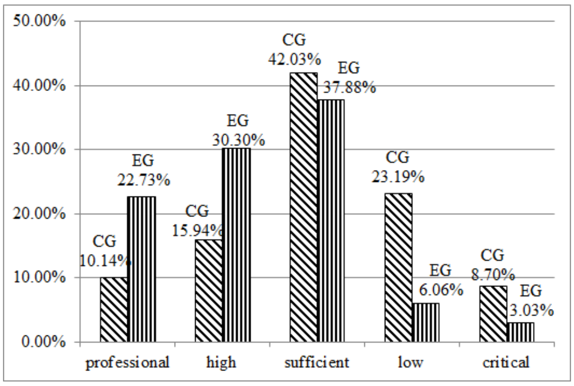

Figure 4: Formation of the reflexive component of students' professional competence (forming stage of the experiment).

Valuation of the obtained data. Testing of the hypothesis about the statistically significant differences in the average values of the formation of components of students' professional competence in control and experimental groups, and therefore different levels of formation of professional competence was generally performed using the Student's t-test.

The null hypothesis: there is no statistically significant difference between the samples, the average values of the indicators of the professional competence components of the students of the control and experimental groups are equal.

Alternative hypothesis: there is a statistically significant difference between the samples. the average values of indicators of the formation of components of professional competence of students in the control and experimental groups differ significantly.

The results of testing these statistical hypotheses are given in table 2.

Table 2: Results of valuation of the obtained data (forming stage of the experiment).

Components of professional competence	t_{emp}	**Conclusion**
motivational	2.85	$t_{emp} > t_{cr}$
cognitive	6.09	$t_{emp} > t_{cr}$
operational	5.32	$t_{emp} > t_{cr}$
reflexive	2.87	$t_{emp} > t_{cr}$

Thus, the statistically significant differences in the levels of components of students' professional competence in control and experimental groups at the formative stage of the pedagogical experiment were proved. So, we can conclude that the average difference is not accidental, but is the result of the implementation of the proposed organizational and methodological conditions for the formation of professional competence of bachelors in Information Technologies in the process of studying object-oriented programming.

4.3 Additional Stage

At this stage of research, the survey method was used, the content of the disciplines of the cycle of professional training of bachelors in Information Technologies was updated taking into account the goals of sustainable development, the implementation of educational projects was organized. The survey was conducted using a modified Olsson questionnaire (Olsson, 2018).

At the formative stage of the experiment, positive changes at the levels of formation of the components of professional competencies of future software engineers have been recorded. In the experimental group, these changes have been more pronounced and at the end of the experiment, there have been significant differences between the control and experimental groups. The share of participants in the experiment with a sufficient and high level of formation of the motivational component of professional competencies (the criterion of formation of internal motivation to continue education and training) in the control group has increased by 12.08%, in the experimental group it has increased by 26.76%; the motivational component (the criterion of formation of internal motivation for professional activity of a software engineer) has increased by 13.52% and 26.77%, respectively; the cognitive component has increased by 5.80% and 19.70%, respectively; the operational component has increased by 10.63% and 23.23%, respectively; the communicative component has increased by 4.83% and 23.23%, respectively; the reflexive component has increased by 15.46% and 28.78%, respectively.

5 FURTHER RESEARCH

Research conducted in 2015–2019 has shown that the introduction of sustainable development issues into the content of curricula influenced positively the quality of training for IT specialists at universities. Of greatest importance is the incorporation of students' educational and scientific projects, when they have the opportunity to get acquainted with the problems of sustainability and the sustainable development goals (SDG) as well as to offer ways of solving them, in particular, through the development of specialized software.

Therefore, at the end of the experiment, it was decided to continue the work on integrating the content of IT education in Bogdan Khmelnytsky Melitopol State Pedagogical University with sustainability issues. We followed the recommendations outlined in (Fisher et al., 2016; Cai, 2010; Hilty and Huber, 2018). In 2020, individual conversations were held with educators of the Department of Informatics and Cybernetics to determine the most promising approaches to achieve this goal. As a result, it was found that component-level integration and course-level integration (according to Fisher et al. (Fisher et al., 2016) classification) are the most expedient.

The first approach is the simplest to implement since it only involves updating the content of training courses and introducing additional topics or modules, as well as changing the types of training activities. Such work has already been partially carried out during the 2015–2019 experiment as part of the training of bachelors in Information Technologies. Therefore, at the next stage, changes were made in the content of the master's training courses, as well as in the topic of diploma projects. Besides, engaging students in the research funded by a grant from the Ministry of Education and Science of Ukraine (No. 0120U101970) to achieve SDG 4 "Quality Education" also helps raise their awareness of sustainability issues.

The second approach was decided to be implemented by introducing new disciplines of students free choice, the content of which is fully devoted to the problems of sustainability. This direction presupposes the formation of completely new content, therefore such courses are now at the development stage.

6 CONCLUSION

The transformation of society to meet the goals of sustainable development is impossible without the active participation of each citizen. Training for such activities should be undertaken at educational institutions of all levels based on Education for Sustainable Development principles.

The realization of the goals of education for sustainable development in the process of professional training of bachelors in Information Technologies implies deep informatization of the educational process, enhancement of opportunities for professional mobility and lifelong learning, improvement of educational programs, the introduction of issues of sustainability and content.

In the process of experimental work, attention was paid to acquaint students with the goals and objectives of sustainable development. We believe that it is advisable to direct further research on the implementation of disciplines and individual modules aimed at familiarizing students with the problems of a sustainable future and understanding of their role in solving these problems in IT curricula.

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The Values of Biological Education from the Point of View of 2020 Events (or Biotechnological Human Improvement through the Eyes of Students)

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Keywords: Terminal Values, Instrumental Values, Biological Education, Human Enhancement, Bioethics, Future Teachers of Biology.

Abstract: The main idea of the research is that the value potential of academic disciplines contributes to the implementation of the idea of sustainable development in the framework of secondary and higher biological education. As a result of a study carried out in 2019, we found that in basic school the content of the subject "Biology" is primarily aimed at the formation of ideas about the main terminal values – "life", "health", "nature"; in high school – about terminal values – "life", "health", and also about instrumental values – "persistence". In our 2020 study, we investigated the influence of the bioethical content of biological disciplines on the formation of value ideas of future biology students and future biology teachers about modern scientific innovations (using the example of genome editing and biotechnological human improvement), the development of the ability to evaluate them from a bioethical point of view. It is assumed that the formation of the ability to give a bioethical assessment of events taking place in the scientific world and ongoing discoveries is one of the main in the implementation of the idea of sustainable development in the field of education.

1 INTRODUCTION

At the beginning of 2020, the world did not even suspect about the consequences of those global challenges and catastrophic changes that would fall on it in an avalanche in a matter of weeks. On December 31, 2019, WHO was informed of the detection of cases of pneumonia of unknown origin in Wuhan, China. Two months later, on March 11, 2020, WHO Director-General Dr. Tedros Adhanom Ghebreyesus will declare that the outbreak of COVID-19 can be described as a pandemic (WHO, 2020). The subsequent chain of events in 2020 became proof that biology in today's world is one of those sciences that develops strategically important mechanisms for the survival of all mankind as a whole and each individual individually. The reverence for biological science, with its realities and possibilities, which has rapidly increased in less than a year, actualizes the need to revise the goals and values of biological education. In the light of the current events, the understanding of the role of biology in ensuring the sustainable future of mankind becomes all the more urgent.

At the 70th session of the UN General Assembly, the 2030 Agenda for Sustainable Development was adopted. It includes 17 new global goals that will be included in the subject field of education for sustainable development (Grachev et al., 2017).

According to the Incheon Declaration (UNESCO, 2015), education is considered as the main driving force for transforming people's lives and achieving sustainable development goals. We are talking about the development of skills, value orientations and behaviours that enable citizens to lead a full, healthy life, make informed decisions and respond to local and global challenges through education for sustainable development and education in the spirit of global citizenship (Grachev et al., 2017).

Education for sustainable development is an international vector of education and enlightenment of a person throughout his life, which is implemented in the interests of human capital development, in order to preserve the cultural and natural heritage of the planet for generations (Dzyatkovskaya and Zakhlebnyi, 2016).

There are several models for the implementation of education for sustainable development: natural sci-

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ence, interdisciplinary and school-wide (Koryakina, 2012). In the framework of the natural science approach, education for sustainable development is considered the successor to environmental education (Koryakina, 2012).

On a global scale, changes in educational systems aimed at adopting the idea of education for sustainable development have been taking place since the early 2000s (Grachev et al., 2017; Koryakina, 2012).

Today, education for sustainable development has two methodological problems (Abdurahmanov et al., 2010).

The first is connected with scientific foundations, since a classical scientific school cannot fully meet the principle of scientificness in modern conditions (Abdurahmanov et al., 2010).

The second methodological problem is the futuristic prognostic nature of education. The growing capabilities of information technology in an irrepressible progression require students to learn how to predict the future steps ahead.

Therefore, it is relevant not only to teach to analyze and draw conclusions, but to predict, envisage the future, and model the activity in the long run. Another difficulty in the formation of education for sustainable development is called the blurring of its content: knowledge, methods of activity and value-semantic attitudes (Dzyatkovskaya and Zakhlebnyi, 2016).

The concept of "sustainable development" is twofold.

On the one hand, sustainability provides stability, fundamentality, in a certain sense stagnation. On the other hand, development is based on transformation, change, improvement.

Out of this we conclude that a system that is in a state of sustainable development includes unchanged or hardly changed fundamentals and permanent deviations, summarizing as a result in a new quality. What constitutes an unshakable foundation, and what is subject to changes in the framework of science education for sustainable development in general and biological in particular, these questions have to be answered.

The effectiveness of any educational system is evaluated according to the final result. According to the culturological theory of the education content, the results of education are knowledge, reproductive experience, experience in creative activity, and experience of an emotional-value attitude to the world (Kraevsky and Lerner, 1981). The need to address just this theory when designing the content of education for sustainable development is indicated in a number of studies (Dzyatkovskaya and Zakhlebnyi, 2016).

A school subject is a didactically adapted system of scientific knowledge about the world and a person's place in it. The volume of scientific knowledge is growing exponentially, therefore knowledge is the most dynamic element of the system.

In the framework of the study, we consider the experience of an emotional-value attitude to the world as the most constant, long-forming and system-forming element of the knowledge system. We consider the formation of an emotional-value component by means of biology as one of the strategic goals of education for sustainable development.

The experience of an emotional-value attitude to the world involves the formation a schoolchild's set of value ideas that guide him in the present and future. At the same time, a personal experience of an emotional-value attitude to the world is formed (Knyazeva, 2015).

The value ideas that make up the personal experience act as regulators of behaviour and factors in the choice of a particular model of action. At the same time, they are the result of a person's assimilation of social and cultural-historical experience.

The selection of the content of a school subject aimed at the formation of value ideas among schoolchildren is based on the value potential of biological science: its cultural and historical component (Knyazeva, 2015), current and future prospects for the development of not only basic science, but science as a whole as part of culture.

The transformation of the value potential of the subject into the value ideas of students occurs with the direct participation of the teacher, who acts as an intermediary between the content of the subject and the emotional and value sphere of the student.

The process has a subjective colouring, because it is based, firstly, on the teacher's understanding of the value meanings of the educational process in general and the educational process in biology in particular, and secondly, on the teacher's personal value ideas.

At different stages of ontogenesis, different values have unequal relevance, which is due to a change in leading human activities.

The chronological principle of constructing a system of values is that values of an earlier age acquire a subordinate position with respect to values of a later period (Sevostianov and Gainanova, 2011).

In the context of science education for sustainable development, such a change has other reasons – there is a constant change in the substantial and process content of academic subjects. These changes are caused not only by regular age-related changes in the cognitive activity of students and the concentration of the subject content around generalizations of science in high school compared with the main school in one cycle, but also by a change in the approaches to the selection and structuring of educational content from cycle to cycle in historical terms.

Within the framework of education for sustainable development, the choice of the "cognitive" component of the content of education is an obligatory stage, since it helps to prevent the blurring of its subject and its transformation into simple information about the problems of sustainable development (Dzyatkovskaya and Zakhlebnyi, 2016).

In 2019, we conducted a study to study the majority structure of values formed by means of biology in basic and high school. The respondents were students – future biology teachers.

The study included theoretical and experimental stages.

The theoretical stage was aimed at solving the following problems:

1) to distinguish between the categories of "value", "value representations of the individual", "value potential of the subject", "value potential of basic science";
2) to differentiate the value representations of a personality according to the subjects of the educational process into "value representations of a student" and "value representations of a teacher";
3) to simulate the process of forming value ideas of students in the framework of the subject.

Methods used at the theoretical stage: analysis of scientific publications concerning formation of students' value ideas, according to the methodology for evaluating the value ideas of an individual.

For the experimental stage, we developed a poll-questionnaire. It included questions to study respondents' attitudes to 11 value categories that belong to two types (Rokeach, 1979): terminal (life, health, beauty, nature, equality) and instrumental values (kindness, striving for truth, freedom, perseverance, justice, creative an approach).

The questionnaire was designed for future biology teachers, whom we consider as a connecting element in the process of transforming the value potential of a subject into value ideas of students. In 2019, 40 students of the Pedagogical University of the specialty "Biology" took part in the survey. The questionnaire was aimed at solving such problems:

1) to establish the majority structure of the school biology course values (poll questions 1, 2, 3, 7, 8, 9);
2) to establish the majority structure of the value representations of future biology teachers (poll questions 4, 5, 6).

We adhere to the approach according to which value is "a firm conviction that a certain mode of behaviour or the ultimate goal of existence is preferable from a personal or social point of view than the opposite way of behaviour, or the ultimate goal of existence" (Leontiev, 1998).

Values have a hierarchical nature, because, unlike norms, they are a system: a personal system of values, a system of values of a society, a professional system of values (Sevostianov and Gainanova, 2011). The hierarchical structure of values also determines that the value system itself should reflect the general properties of hierarchical systems (Sevostianov and Gainanova, 2011). Speaking about the concrete-applied significance of axiology in the school educational process, and therefore about the concrete embodiment of the idea of sustainable development in education, it is important to solve a number of issues. For example, should a system of values formed by means of a subject of biology, chemistry, ecology reflect the properties of biological, chemical, ecological systems? Or should one proceed from such general properties of systems as integrity, emergence, subordination, reliability, adaptability, etc., irrespective of subject matter?

In the latter case, the value systems formed in the educational process when studying different educational subjects of the natural science cycle are characterized by the same properties with different content. More specifically, the problem can be formulated as follows: are terminal values such as life, health, nature - the values formed by the means of all subjects of the natural science cycle or only biology?

The study of this question will give an answer about what values, value ideas should be formed in the light of implementation of the idea of sustainable development in education when studying the subjects of the natural science cycle individually and as a whole. Let us note that there are successes in finding the answer to this question. Education for sustainable development should be subject-related (Dzyatkovskaya and Zakhlebnyi, 2016; Ryzhakov, 1999; Ivanova and Osmolovskaya, 2012). Within each subject-oriented invariant (ecologically-centred, economically-centred) a varied content is built taking into account the local educational and cultural context. The subjectivity of education for sustainable development helps to prevent the blurring of topics identified by UNESCO as priority within the main topics of discussion in education for sustainable development (UN Economic and Social Council, 2005).

In the model constructed around the "ecological imperatives" invariant, the personal meanings of the ecological imperative are the system-forming factor in the content of education for sustainable development (Dzyatkovskaya and Zakhlebnyi, 2016).

We found that in literature the concepts of "values", "value orientations", and "value representations" are often confused. The latter are not reducible either to values, as really acting immanent regulators of human activity, or to value orientations, as conscious representations of a subject about his own values.

Value representations of a personality are a complex dynamic category, including its value orientations, value ideals, value stereotypes, value retrospective, etc. (Leontiev, 1998).

The valuable potential of an educational subject is the subject content, which reveals the social and personal significance of the material being studied.

The valuable potential of basic science is the totality of objective knowledge about social and natural reality, the leading motive for which is the need to know nature, rather than gaining control over natural objects (Vlasova, 2014).

In the course of solving the second and third tasks, we came to the conclusion that:

- teacher's value ideas are factors of the formation of students' value ideas;
- formation of teacher's value ideas that are adequate to the modern level of science, society and culture development, is one of the tasks of his professional training;
- the process of forming students' value ideas within the framework of a school subject looks like this: "value potential of basic science" $\rightarrow$ factors of selecting the content of education $\rightarrow$ "value potential of a school subject" $\rightarrow$ "value ideas of a teacher" $\rightarrow$ "value ideas of a student".

The content and results of a survey conducted at the experimental stage are given below.

1. Do you agree that the content of the subject "Biology" is aimed at the formation of value ideas of students?

   Results: a) clearly "yes" – 63%; b) more likely "yes" than "no" – 28%; c) rather "no" than "yes" – 9%; d) clearly "no" – 0%.
2. Is the content of the subject "Biology" in the basic school, in your opinion, aimed at forming ideas about what values? Arrange them in descending order: kindness, life, health, aspiration for truth, beauty, nature, freedom, equality, perseverance, justice, creativity.

   Results: nature – 86%, life – 74%, health – 74%, beauty – 20%, creativity – 6%, freedom – 6%, kindness – 6%, equality – 3%, striving for truth – 3%, perseverance – 3%, justice – 3%.
3. What values creating is the content of the subject "Biology" in high school, in your opinion, aimed at? Arrange them in descending order (the options are the same as in question number 2).

   Results: health – 54%, life – 49%, perseverance – 46%, nature – 40%, striving for truth – 17%, beauty – 11%, equality – 11%, creativity – 9%, justice – 9%, freedom – 6%, kindness – 3%.

   The results of the answers to questions 2 and 3 are summarized in figures 1, 2 and 3 (dark line – basic school results, light line – high school results).
4. Arrange the values in order of decreasing their priority for yourself (the options are the same as in question No. 2).

   Results: life – health – nature – perseverance – justice – equality – freedom – beauty – kindness – creativity – striving for truth.
5. Select three synonyms for the word "valuable" from the list: expensive, long-awaited, deserved, promising, useful, pleasant, fair.

   Results: expensive – 49%, long-awaited – 31%, well-deserved – 37%, promising – 29%, useful – 60%, pleasant – 20%, fair – 20% (results are presented in figure 4).
6. Rate the following statements (I agree with – the "+" sign, I do not agree with – the "-" sign):

   a) valuable is what is important and useful for me – 86%; b) valuable is what is important and useful for my loved ones – 86%; c) valuable is that which is important and useful for society – 74%; d) valuable is that which is important and useful for nature – 94%.

So, in 2019 we came to the following conclusions:

1. In the basic school, the content of school biology is primarily aimed at the formation of ideas about terminal values – "life", "health", "nature".
2. In high school, the content of the subject is primarily aimed at the formation of ideas about terminal values – "life", "health", as well as instrumental value – "perseverance".
3. In the biology course of high school, as compared with the basic one, the orientation toward the formation of ideas about the terminal values of "life", "health", and "nature" decreases.
4. In high school, the focus is on the formation of ideas about instrumental values "striving for truth" and "perseverance."

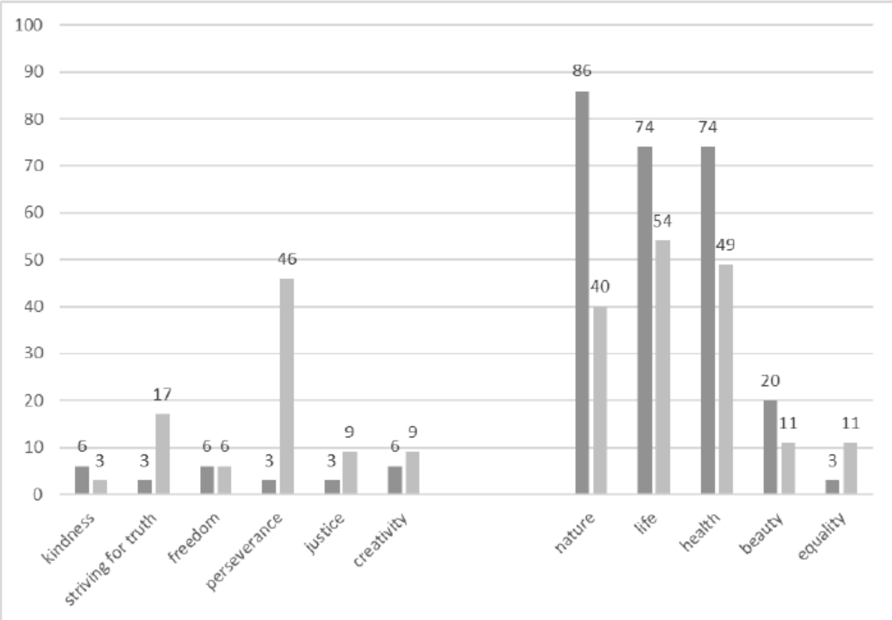

Figure 1: General results on the selection of values of a school biology course.

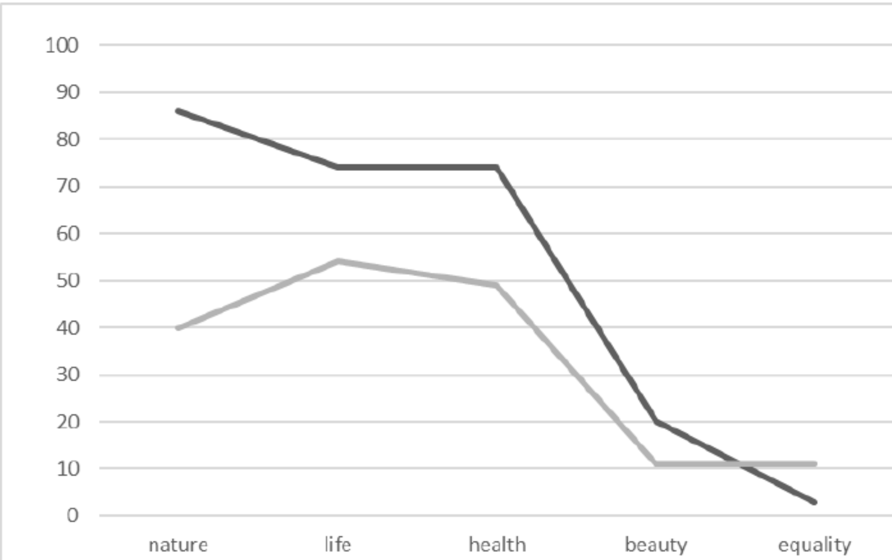

Figure 2: Majority system of terminal values.

5. In general, the school biology course is more focused on the formation of ideas about terminal values than instrumental ones.
6. The results can be considered as confirmation of the chronological principle of building a system of values in ontogenesis.
7. In the majority structure of value ideas of future biology teachers, the three leaders are orientations towards terminal values: life, health, nature.

In the course of an experimental study, it was found that such instrumental values as a creative approach and the aspiration for truth do not find a worthy representation in the majority list of value ideas of respondents.

On the one hand, such a result is relevant, on the other hand, it is not very charitable from the point of view of a positive assessment of the readiness of future teachers for professional activities for the implementation of sustainable development ideas in biology education.

The majority structure of the selected synonymous

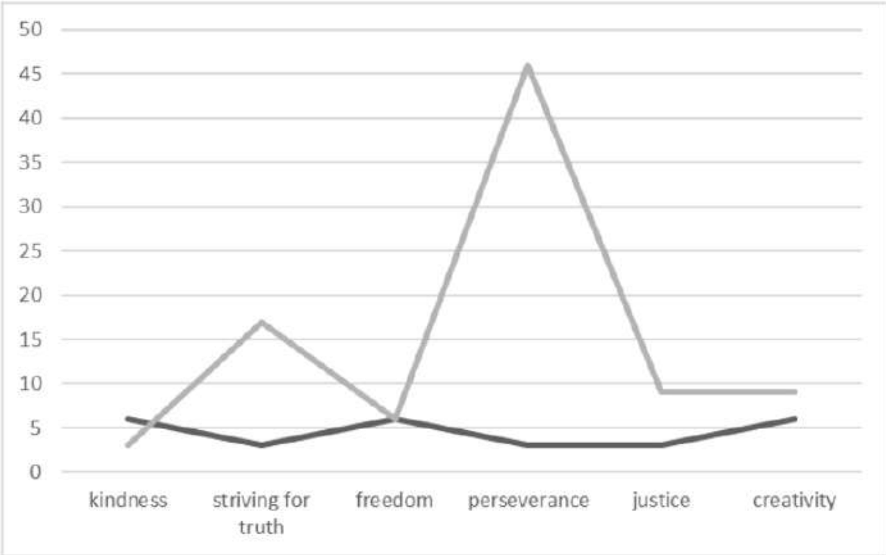

Figure 3: Majority system of instrumental value.

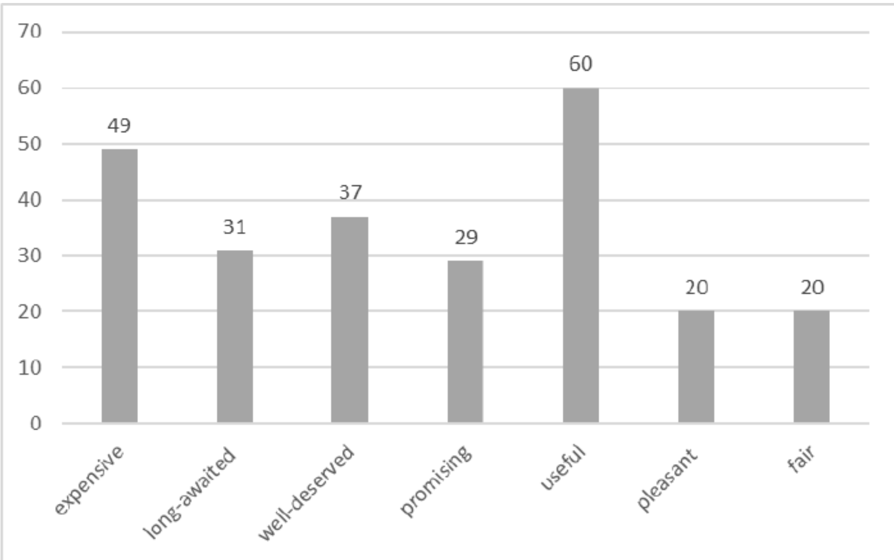

Figure 4: The respondents' choice of synonyms for the word "valuable".

terms (task 5) demonstrates that the respondents attribute to values the following: firstly, something having a utilitarian focus (valuable – useful), secondly, something which is expressed in significant material equivalent, and thirdly, something which involves the application of certain efforts.

We saw further directions of research in 2019 in the following (Komarova and Starova, 2020):

- establishing the causes of the revealed differences between the value potential of the subject "Biology" and the value ideas of the participants in the educational process, that is, between their declared and real values;
- elucidation of the nature of reflection of differences in the fulfilment by teachers of biology of professional activities in the framework of education for sustainable development;
- the study of the ratio of declared and real values (value ideas) of students;
- study of the microstructure of personality value representations of a biology teacher and a student studying biology (value orientations, value stereotypes, value ideals, etc.);
- modelling the process of value ideas formation of a biology teacher as a factor in the formation of

students' value ideas solving the problems of education for sustainable development;

- modelling the process of forming value representations of students' personality by means of school biology in the framework of education for sustainable development.

In 2020, humanity is facing a biological challenge. The coronavirus pandemic and ways to overcome it immediately found a response in the global scientific community. Prioritizing medical care during a pandemic, restricting rights and freedoms, developing vaccines, conducting clinical trials, introducing new vaccine registration standards and their widespread use in a pandemic (Emanuel et al., 2020; Fidler, 2020), principles of distribution of vaccines between countries and population groups, risks associated with vaccination, social consequences ... These and many other issues are united by one thing – the bioethical component: risks, information, consent, choice, fairness, voluntariness.

And so, in October 2020, another significant event took place in the natural science world, which stirred up the scientific community. We are talking about the award of the Nobel Prize in Chemistry in 2020 (www.nobelprize.org, 2021). "Emmanuelle Charpentier and Jennifer A. Doudna have discovered one of gene technology's sharpest tools: the CRISPR / Cas9 genetic scissors. Using these, researchers can change the DNA of animals, plants and microorganisms with extremely high precision. This technology has had a revolutionary impact on the life sciences, is contributing to new cancer therapies and may make the dream of curing inherited diseases come true" (www.nobelprize.org, 2020).

This discovery in 2012 was a breakthrough not only in the natural sciences industry (Meloni, 2014). According to scientists, it turned the sphere of humanitarian knowledge, updated a number of issues related to the identification of the human essence (Lukov, 2017; Buynyakova, 2017, 2019; Allhoff et al., 2009; Masci, 2020).

The discovery of the mechanism of genetic scissors and the study of its use for editing the human genome will force us to take a fresh look at the significance in the life of each individual and society as a whole of the terminal values "life", "health", "equality", instrumental values "kindness", "freedom", "justice". We assume that the issues of good, justice, equality and the opposite issues of evil, unjustified, infringement of rights will be updated with renewed vigor in the public discussion of the prospects and consequences of editing the human genome. In light of this, the discussion of the possibilities and consequences of "human improvement" will take on new turns. In the context of the issue of the value potential of biological education, we are interested in the bioethical component of the problem of human enhancement. Editing the human genome will make it possible to modify the biological essence of a person, but is this the general goal that humanity should strive for? What are the risks and benefits of further research in this area? Does the benefit outweigh the risk, is the risk justified? Will the biotechnological enhancement not entail a leveling of the social component of the human essence, will not the uniqueness of the human personality as a whole be reduced to nothing? Will the goals and values of human life change and how?

These and similar questions naturally arise both in philistine circles and among representatives of the scientific community: biologists, philosophers, sociologists. They become the subject of heated discussions, and require the earliest possible discussion and solution.

It should be noted that the study of the problem of people's attitudes towards the possibility of biotechnological enhancement is not new. The results of a study of public opinion using focus groups on such areas of enhancement as genome editing, chipping, and the use of artificial blood obtained in 2016 are very interesting (Rainie et al., 2016; Funk et al., 2016). In general, the results of the survey in 2016 showed a negative attitude of respondents to the possibilities of human improvement in all three areas.

So, 2020 is the year of the beginning of a new wave of discussion of the bioethical component of science, biological science. It is natural that social and scientific events of 2020 cannot but affect different spheres of public life. They find reflection in the revision, clarification, transformation of the previous goals and value meanings of both the sphere of education and subjective values.

Among the promising directions in the study of the value orientations of biological education voiced earlier in the article were named:

- study of the microstructure of value representations of the personality of a biology teacher;
- modeling of the process of forming value ideas of a biology teacher.

What has been done in this direction, what results have been obtained and what conclusions have been formulated for further work in the direction of studying the content and transformation of the value meanings of biological education?

In 2020, the study was conducted on the basis of the Immanuel Kant Baltic Federal University.

2 TECHNIQUE AND METHODS

At the Immanuel Kant Baltic Federal University, preparation of students for professional pedagogical activity is carried out within the framework of the study of an elective pedagogical module. The study of the module according to the curriculum takes place in the 5th or 6th semester for students of the specialty “Biology”. The content of the module is limited by the narrow framework of study time (12 hours of lectures and 12 hours of practical training). This is the reason that the study of issues of bioethical content, which we consider extremely important for the formation of value concepts of future teachers of biology, we moved into the content of other academic subjects: the discipline “Fundamentals of Theoretical Biology” (72 hours) and “Bioethics” (60 hours). The number of academic hours for the study of these disciplines is much more than for the study of the pedagogical module. Therefore, the axiological foundations of biological science and education, their bioethical component are extensively presented by us in these courses.

In the first half of 2020/2021, within the 9th semester for 4th year students of the specialty “Biology” in the 7th semester, the course “Fundamentals of Theoretical Biology” was delivered. At the same time, the course “Fundamentals of Bioethics” was taught for 5th year students of the specialty “Biotechnology and Bioengineering”. The course content included bioethical issues relevant in 2020 for the development of biological science. After studying the above disciplines, the students of the Institute of Living Systems were invited to take part in the survey “Biology and Ethics of Human Improvement”. The survey was also attended by 1st year students, for whom disciplines with bioethical content were not read in the 1st semester.

The survey form is online using Google Forms templates.

The purpose of the survey is to identify among the student youth, who have chosen natural (chemical and biological) sciences as the sphere of their professional interests, a value attitude towards the development of modern biology using the example of the problem of human biotechnological enhancement.

Tasks of the survey:

- to identify students’ understanding of the essence of the bioethical component of scientific research (using the example of the problem of human biotechnological enhancement);
- to establish the necessity, format and topics of discussion of modern bioethical problems.

80 students took part in the survey (57 1st year students, specialty “Biology”, “Chemistry”, “Biotechnology and Bioengineering”, 9 5th year students, specialty “Biotechnology and Bioengineering”, 14 4th year students, specialty “Biology”). Closed and open questions were proposed.

3 RESULTS

The content and results of the survey are presented below.

1. Do you think that human improvement can be a modern biotechnological project?

Variants of answer: unequivocally “yes”, unequivocally “no”, rather “yes” than “no”, rather “no” than “yes”, I find it difficult to answer, my own version. The results of the answer are shown in figure 5.

The results show that 5th year students are more cautious in their assessment of considering human improvement procedures as a biotechnology project. At the same time, caution is manifested not only in a decrease in the choice of a sharply positive answer (22.2% versus 43.9% and 50% in the other groups). Characterized by the complete absence of a choice of a sharply negative answer, and a weakly negative answer (0% versus 10.5% and 7.1% in the other groups).

The results of the answers of the 1st and 4th year groups are close in values.

The reason for the difference in answers between the 1st, 4th and 5th courses may be in the specifics of the specialties for which students are trained. The 5th year students of the specialty “Bioengineering and Bioinformatics” approach the reality of “improving” a person from a utilitarian and practical point of view. Students of the specialty “Biology”, not having sufficient professional knowledge, more easily assess the potential of human enhancement.

In general, the majority of the respondents consider human enhancement as a possible modern biotechnological project.

2. Do you consider it possible from an ethical point of view to intervene in the human genome, edit it?

Answer options see in item 1.

The results of answering this question allow us to state that for students of the specialty “Bioengineering and Biotechnology” it is more acceptable from an ethical point of view than for students of the specialty “Biology”, is the possibility of editing the human genome. It can be assumed that this result is due to the same reason that was named in the previous question. Future biotechnologists and bioengineers consider the human genome as an object for instrumental impact due to the peculiarities of their professional training.

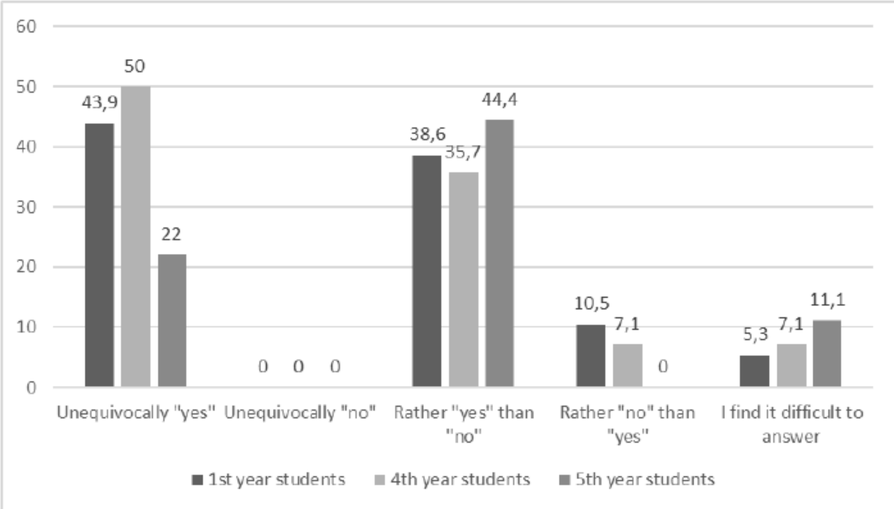

Figure 5: Results of the answer to the question "Do you think that human improvement can be a modern biotechnological project?".

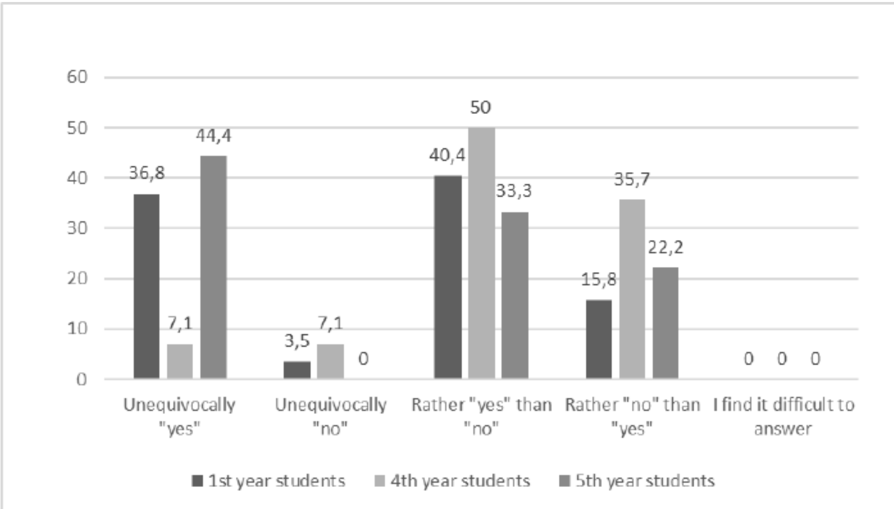

Figure 6: Results of the answer to the question "Do you consider it possible from an ethical point of view to intervene in the human genome, edit it?".

The results in groups of biology students turned out to be very interesting. So, for 1st year students, the answers with a sharply positive answer and a weakly positive answer in total are the same as for biotechnology students (36.8% and 40.4% for biologists and 44.4% and 33.3% for biotechnologists). For fourth-year biologists, the share of sharply positive answers is only 7.1% (versus 36.8% for first-year students and 44.4% for fifth-year students). The total amount of negative answers for fourth-year biologists is 42.8% (sharply negative 7.1%, slightly negative 35.7%) versus the total amount of negative answers among first-year students – 19.3% (sharply negative 3.5%, weakly negative 15.8%) and 5th year students 22.2% (sharply negative 0%, slightly negative 22.2%).

A possible reason may be that for the 4th year students, the bioethics course was not read until the moment of the questionnaire, in contrast to the 5th year students. But for the 4th year students the course "Foundations of Theoretical Biology" was taught, the content of which laid the foundations of modern bioethical knowledge. In addition, the methods of practical work with 4th year students included holding round tables in full-time format, in contrast to the defense of project work in an online format by 5th year students. Also, for 4th year students, such a form of work was introduced as writing an essay on bioethical topics and its defense. The form of intermediate control for 4th year students in mastering the discipline “Foundations of Theoretical Biology” was written control papers with open questions of a debatable nature. For 5th year students, intermediate control was not carried out.

In parallel with the above explanation, the problem arises of explaining the results for 1st year students. We believe that this issue requires further study.

We assume that the study of the course “Foundations of Theoretical Biology” has a positive effect on the formation of elements of bioethical knowledge of students – future biologists. This issue also requires further study, especially considering the fact that the same students will have to study the course “Bioethics” in the 8th semester, in an amount of hours that is 2 times the volume of the discipline “Fundamentals of Bioethics” for 5th year students of the specialty “Biotechnology and Bioengineering”.

3. Do you think that interference with the human genome is dangerous?

Variants of answer: yes, no, I find it difficult to answer.

The results of the answer to this question demonstrate the significant caution of the respondents regarding the safety of human biotechnological enhancement. It is noteworthy that 5th year biotechnology students are most cautious. 1st year students are the most optimistic. How do we explain these results? We assume that the reason is the lack of experience in professional biological training, the immaturity of the position on ambiguous scientific problems, insufficiently formed scientific critical thinking.

4. What kind of danger can occur when trying to biotechnological enhancement of a person? There are several options to choose from.
   - A person’s loss of his self-sufficiency as a natural phenomenon;
   - Difficultly predictable biological consequences;
   - Aggravation of ethical problems, for example, associated with limited access to the genome improvement procedure - a service only for the rich;
   - The problem of elitism of “improved” genomes in comparison with natural genomes, increasing social inequality;
   - Rough interference with natural mechanisms developed over millions of years will change the course of the evolutionary process and disrupt its course;
   - No dangers, only advantages.

The results of the answer to the question differ in the groups of students. For 1st and 5th year students, the greatest danger is difficultly predicted biological consequences. For 4th year students, the greatest danger is problems of possible social inequality and the threat of the emergence of elitism of “improved” genomes. For 1st and 5th year students, such a danger as a person’s loss of his self-sufficiency as a natural phenomenon is in last place. For 4th year students, this danger is very significant, it is in second place in the choice.

The reason for this difference, we consider the work with students to study the discipline “Foundations of Theoretical Biology”, as mentioned above. The content of the discipline provided for the study of the topic of bioethical orientation and forms of work, involving the conduct of a free discussion, expressing one’s own position on the issue of discussion. Among the practical forms of studying the discipline “Fundamentals of Theoretical Biology” listed above in paragraph 2, we used such a form of extracurricular work as watching feature films – products of world cinema – with a pronounced bioethical orientation, followed by a collective discussion of controversial issues. The study of the effectiveness of such forms of work in the formation of students’ value ideas, in increasing their bioethical literacy and responsibility requires further work. We consider it premature to talk about final results.

5. Do you think that the problem of biotechnological enhancement should be transparent for public discussion?

Variants of answer: yes, no, I find it difficult to answer.

According to the results of the questionnaire, more than 70% of all respondents in each of the groups of students are inclined to open public discussion of the problems of biotechnological enhancement. We explain the differences in the choice of a negative answer by the fact that biotechnology students, due to their professional training, are more inclined to consider the human genome as an object for instrumental influence. In this case, as for any other biological object with which instrumental actions are carried out, discussions are permissible only in a narrow circle of professionals who have education and experience in carrying out the appropriate manipulations.

It is noteworthy that only 1st year students do not consider biotechnological enhancement as a potentially dangerous procedure, do not see any negative consequences of its application. A possible explanation can be considered the same increase in the volume of special knowledge among 4th and 5th year

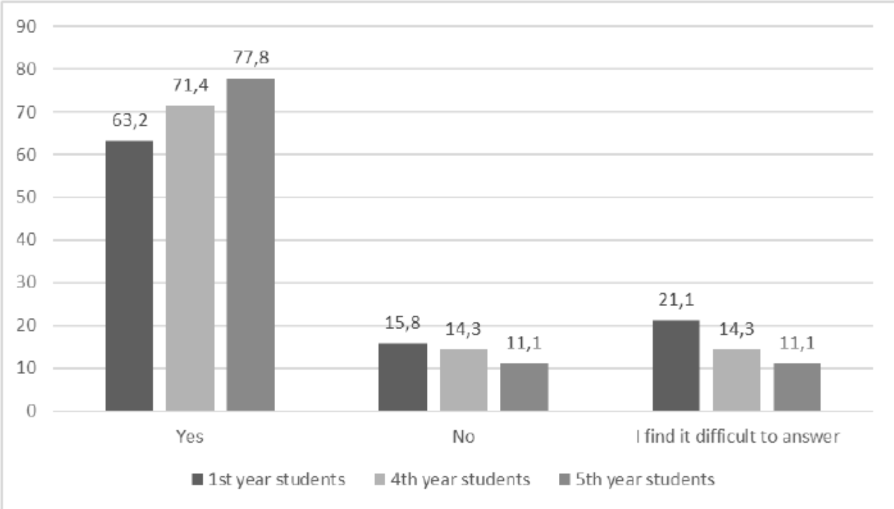

Figure 7: Results of the answer to the question “Do you think that interference with the human genome is dangerous?”.

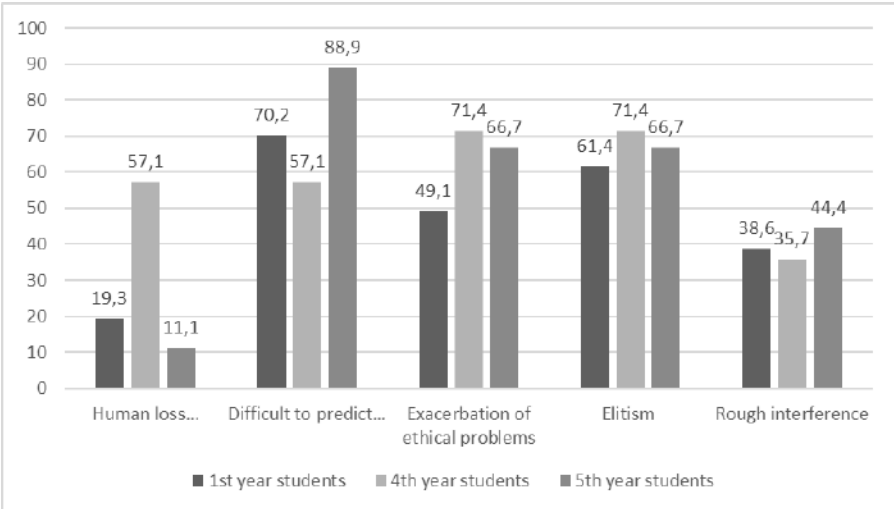

Figure 8: Results of the answer to the question “What kind of danger can occur when trying to biotechnological enhancement of a person?”.

students, the greater criticality and alternativeness of their professional thinking.

6. In your opinion, the possibility of genome editing is:
   - Solving many problems that were impossible to solve earlier (creating resistant genomes to infections, senile diseases, malignant tumors);
   - One of the mechanisms for providing access to the resources and benefits of mankind to a small oligarchy;
   - The reason to receive the Nobel Prize, but in fact it will not come to practical use.

The results of the answer to question 6 demonstrate the confidence of the respondents that genome editing will provide an opportunity to solve a number of problems in which biological science was previously powerless. However, 4th year students in their answers also speak out in favor of the fact that such manipulation will increase inequality between people, lead to stratification of society and can cause social conflicts. The results of 28.6% are indicative enough to be taken into account in assessing the formation of students’ understanding of the value potential of biological science and modern scientific achievements. We assume that the reasons for the differences in the group of 4th year students are similar to those named in paragraphs 2, 4.

7. Would you like to know more information about human improvement through biotechnology?

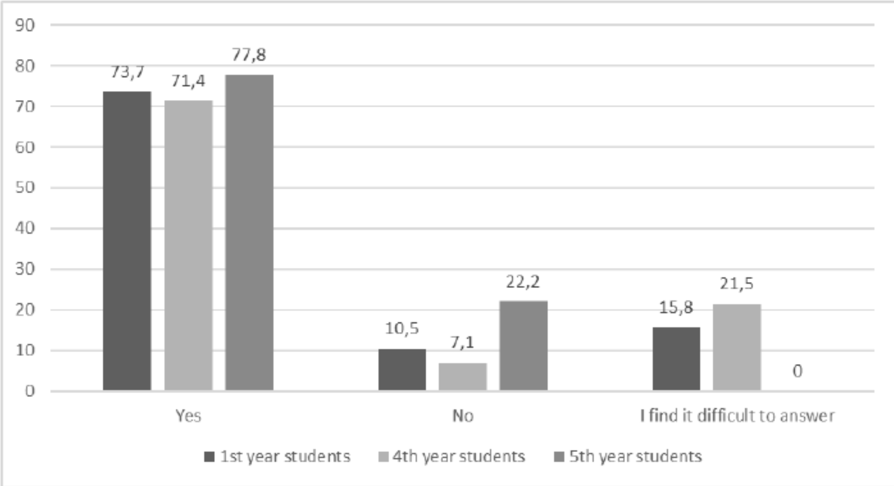

Figure 9: Results of the answer to the question “Do you think that the problem of biotechnological enhancement should be transparent for public discussion?”.

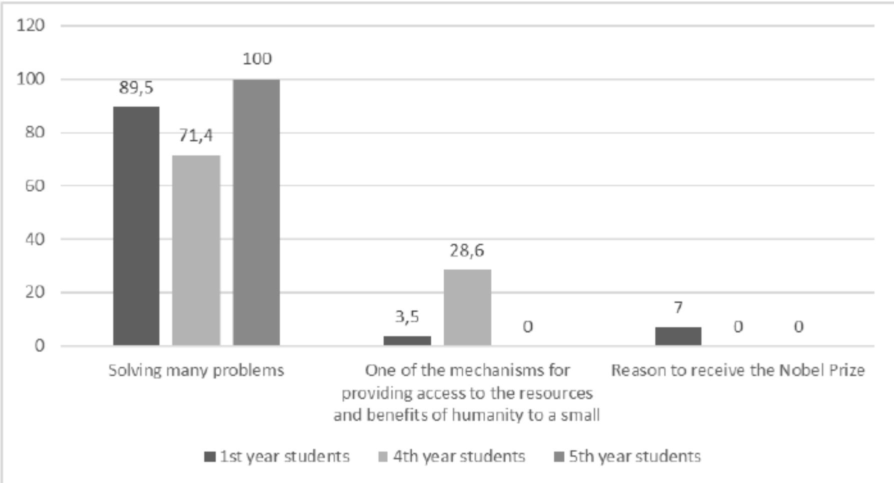

Figure 10: Results of the answer to the question “In your opinion, the possibility of genome editing is?”.

- Yes;
- No.

Students of all groups are unambiguous in their desire to learn more about the possibilities of biotechnological enhancement. However, the results show that the group of 4th year students has the largest number of answers with negative choice in comparison with other groups. We assume that the reasons for this difference are similar to those named in paragraphs 2, 4.

8. What kind of information would be interesting for you?
   - The history of the human enhancement;
   - Ethical issues related to the improvement of the genome;
   - Mechanisms and types of enhancement;
   - Risks of enhancement.

For students of all groups, the most interesting questions are related to risks, mechanisms and types of enhancement. The least interesting topics are related to the history of human enhancement. We can explain the results obtained by the fact that it is inherent in student youth to think in terms of “here and now”, to receive actual, not retrospective knowledge.

9. In what form would you like to learn more about enhancement?
   - Lecture;
   - Round table;
   - Webinar;
   - Independent reading of specialized literature.

The results of the answer to this question allow us to state the presence of a tendency: from 1 to 5

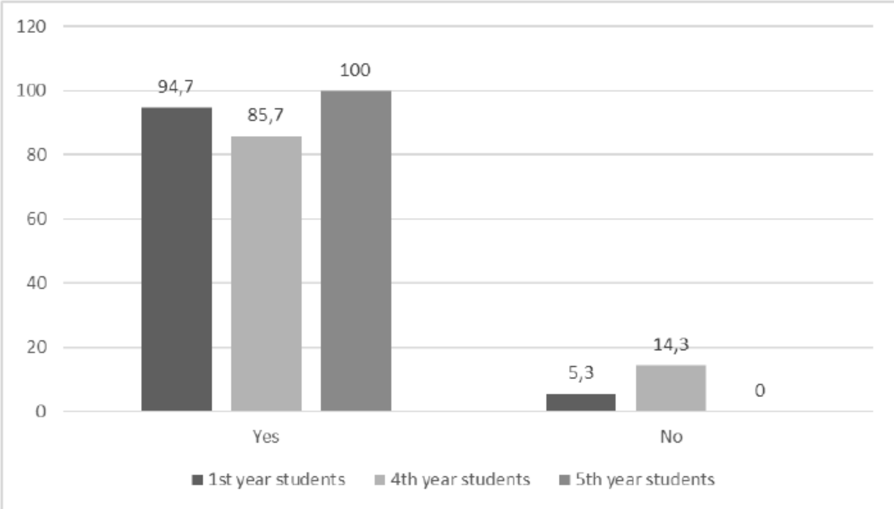

Figure 11: Results of the answer to the question "Would you like to know more information about human improvement through biotechnology?".

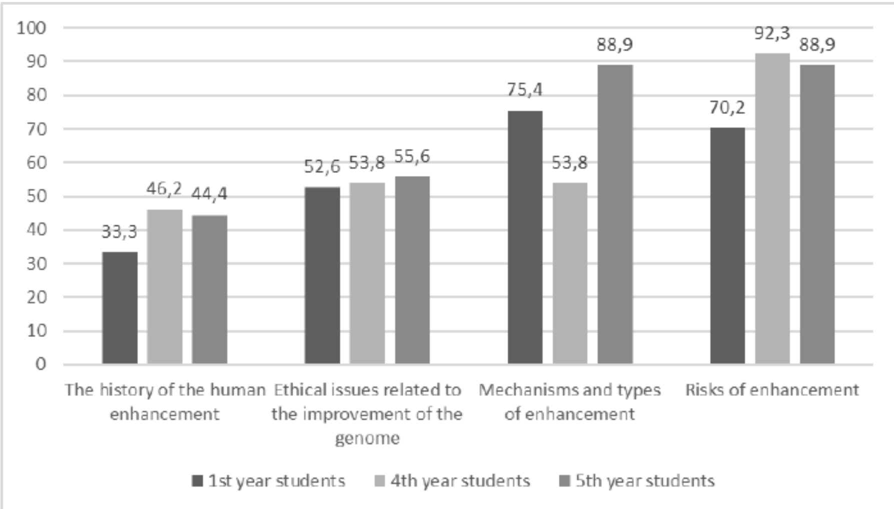

Figure 12: Results of the answer to the question "What kind of information would be interesting for you?".

courses, the importance of monologue teaching methods decreases and the importance of dialogic methods increases when studying issues of bioethical content, in particular, concerning biotechnological enhancement.

We assume that such results can be associated with the use of active teaching methods – round tables, defense of design works, presentation of essays in the study of the discipline "Fundamentals of Theoretical Biology" in the 4th year and "Fundamentals of Bioethics" in the 5th year.

We assume that the redistribution of the types of classroom work with students towards an increase in the number of hours for the practical part by reducing the lecture part of the course can be effective in shaping the value concepts of students, in increasing their bioethical literacy and responsibility.

10. Name three words that come to mind when you say "human improvement":

The results of the answer to this question are presented in the table 1. Note that in the table in bold those words are highlighted that within each group occurred 2 or more times. In addition, we considered the same root words as identical (for example, new and novelty, cyborg and cyborgization, etc.).

The results of the answers to this question are such that in the group of 1st year students there is a maximum number of single-root words used – 21.8% (in comparison with the group of 4th year students – 3.0%, and 5th year – 0%).

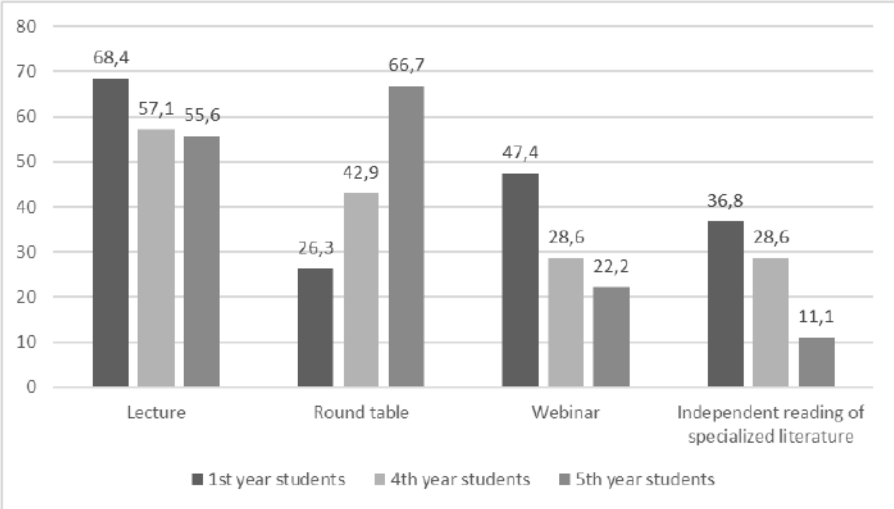

Figure 13: Results of the answer to the question "In what form would you like to learn more about enhancement?".

Also, among all the answers of students from each of the groups, we isolated words-associations with a uniquely negative content (for example, social stratification, break, vice, etc.). These association words are shown in italics in the table.

As a result, we received the following results: in the group of 1st year students the least number of words with negative associative meaning (8%), among 4th year and 5th year students – 18.8% and 12.5%, respectively.

We consider this result not accidental. The reasons mentioned in clauses 2 and 4 can serve as explanations.

At the same time, the results obtained on the last question will be useful for a deeper lexical and semantic analysis of the language units used by students. We assume that this will provide interesting data on the formation of an associative image in people regarding scientific innovations, in our case, on the possibility of genome editing and human biotechnological enhancement.

We attribute to the difficulties of the conducted research:

- participation in the experiment for one group of students from the 4th and 5th year of the specialty "Biology", "Biotechnology and Bioengineering";
- no repetition in experimental learning (no technical replication). It will be conditionally possible to theoretically implement it only in the next academic year, comparing the actual results for today with the future ones;
- the implementation of the previous point is unlikely to lead to reliable results, since the growth rates of scientific biological knowledge are high. To predict how the other spheres of public life interconnected with the scientific sphere will change seems at the moment an almost impossible task;
- attempts to carry out quantitative account of the cash generated by the person values are associated with methodological difficulties, since the category of "value" – it is still the category of quality, not quantity.

4 CONCLUSIONS

The conclusions we formulated as a result of our research at the end of 2020:

- the interviewed students recognize the importance of the bioethical component of modern scientific developments in biology;
- the majority of the students surveyed express their readiness and desire to discuss issues of the bioethical nature of scientific innovations. This makes it possible to assume the possibility of a positive influence on the formation of terminal and instrumental values of students through appropriate training;
- introduction into the curriculum of training students of biological specialties of the discipline "Fundamentals of theoretical biology" with the study of issues of bioethical content is advisable. The positions of students who studied this discipline (4th year) on a number of issues of bioethical content differed from those who did not study the discipline (1st year and 5th year). It should be

Table 1: Results of the answer to the question "Name three words that come to mind when you say "human improvement?".

Group of 1st year students	**Immortality**, business, bioengineering, biology, biotechnology, biohacking, bioethics, the fight against cancer cells, **the future**, eternity, power, **perhaps only education**, **opportunities**, necessity, endurance, **genetics**, genetically ideal people, genetic diseases, **genius**, genetic engineering, genome, money, kindness, **longevity**, eugenics, *universal soldier*, *social stratification*, life, **health**, perfection, danger, *emperor*, **cyborg**, *colonization*, treatment, longevity, better life, mechanism, dream, brain-computer interfaces, **science**, inequality, **novelty**, morality, education, opportunities, **danger**, perfection, absence of diseases, increase of mental abilities, benefit, help, *vice*, posthumanism, revolution, limits, problem, **progress**, prosthesis, processor, **development**, adaptation, *superiority*, *break*, solution, risk, **self-development**, superintelligence, increased life span, **superman**, **superintelligence**, **strength**, death, **perfection**, ability, old age, with perseverance, happiness, transhumanism, mind, civilization, chipping, chips, **evolution**, ecology, experiment
Group of 4th year students	Safety, biotechnology, neurointerface, diseases, **future**, HIV, power, opportunities, longevity, eugenics, ideality, change, immunity, *end of the world*, *I will not see*, *inaccessibility*, victory over hereditary diseases, the appearance of "superpowers" in a person, *obstacle*, progress, prosthesis, *against nature*, development, *regression*, editing the human genome, birth, complexity, improvement, technology, stability, physical condition, perfection, ethics
Group of 5th year students	CRISPR/Cas, adaptation, upgrade, botox, genome, eugenics, cure, liposuction, *not now*, useful, risks, self-development, superman, improvement, *what will God say?*, enhancement

noted that the students who studied were more inclined to understand the social consequences and risks of biological innovations than others. We explain this by the content of the discipline, which considered the history of biology, the direction of development of modern branches of biology, as well as the forms of education used. This was mentioned above when explaining the results of answers to individual questions;

- to assess the level of formation of terminal and instrumental values among students of biological specialties seems to us a global large-scale issue. It is unambiguous that it is impossible and impractical to make a quantitative assessment of the formed values. The need for a qualitative assessment rests on the question of whether the values formed through the educational process should differ among students of biological specialties. In other words, should different terminal and instrumental values be formed in students – future biologists and students – future teachers?

5 OUTLOOK

Summing up, we note that our further research in the direction of the value meanings of biological education posed more questions than answered. We can only assert unequivocally that the training of future biologists, including those who will continue their professional activities in the field of education, must include a thorough bioethical training. It will allow future biologists-scientists and future biology teachers to navigate the present and future world, to make informed choices, and make informed decisions.

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The Learning-style-based Approach and Optimal Use of e-Resources in Teaching Ecological Disciplines

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Abstract: The paper aims to optimise electronic resources used in teaching ecological chemistry following the educational preferences of students. An approach is used to select e-resources in accordance with the available individual learning preferences of students, teaching styles of teachers and the content of the discipline. The R. Felder and B. Soloman model studied the learning preferences of students of Kryvyi Rih State Pedagogical University majoring in chemistry and informatics and students of Kyiv National University of Technologies and Design majoring in industrial pharmacy. Most students in both groups study visually, sensitively, actively and sequentially. Didactic materials on the theme "Ecological chemistry of the lithosphere" of the content module "Ecological chemistry of environmental objects" were elaborated according to student groups' learning profiles. Expanding the content of the course of ecological chemistry is proposed by including an additional topic on the problems of environmental pollution of medicinal plants. The new topics' content is considered to better match the educational material with the prevailing sensitive learning style in most students and simultaneously strengthen the ecological component and form the necessary competencies in future professionals. Forms of work that involve the use of different cognitive functions are described and therefore contribute to their balanced development. It allows a person to be flexible in the unrestrained development of technological progress, be open to different ways of obtaining information, and perceive it without resistance and stress.

1 INTRODUCTION

Sustainable development of society implies the development of the economy, which provides natural systems' ability to recover and exist stably. Under such conditions, resources are used to meet human needs without erosion of natural systems' integrity and stability. The goals in sustainable development, formulated at the UN level, aim to solve global problems. One such global goal is to make people aware of their responsibility for the results of their activities.

Education for sustainable development is defined as education that guarantees knowledge, skills, values and views to ensure a more sustainable and fair society. Education should train professionals to address the growing and changing environmental challenges facing the planet (Ashford, 2004). Accordingly, education must change to provide knowledge and attitudes that will enable students to contribute to sustainable development. At the same time, education should be strengthened in all programs and activities that promote sustainable development. Sustainable development must be integrated into education, and education must be integrated into sustainable development.

The educational process organisation needs to be changed because each individual's development must become "sustainable". Student understanding of the ecological consequences of people's activities in every day and productive spheres of their lives should also become deep and internal. During the integration of appropriate approaches into training, the authors tried to move in two directions. The first is to improve or change the forms and methods of learning, creating conditions for individuals' sustainable development. The second direction changes the content of

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academic disciplines by filling academic programmes with factual data. Such data should reflect the actual state of things in the real world. They should illustrate the relationships in the chain of human activities – the state of the environment (controlled or uncontrolled changes) – result (risks and dangers for people).

Concerning the first approach, teachers should pay more attention to students' learning styles. Education for sustainable development provides an exciting vision of an interdisciplinary and learner-centred way to empower students to advance a pro-social and environmental agenda in their organisations, communities and personal lives. Introducing a student-centred higher education model requires considering the subject's preferences regarding study methods (Saarinen et al., 2020; Damsa and de Lange, 2019; Gao, 2014). Such an approach will allow students to use their available cognitive functions and improve their gnostic functions to develop rapidly.

Students differ significantly in the speed and manner in which they master new information and the confidence they process and use it (Lee et al., 2010; Coffield et al., 2004). With the development of information and communication technologies (ICT), the range of electronic resources (e-resources) and tools that are used or can be used in the educational process significantly expands (Osadcha et al., 2020; Kholoshyn et al., 2020). Such a statement is especially true of teaching natural sciences (Nechypurenko et al., 2020b; Modlo et al., 2020). Accordingly, the problem of individual perception of students of different resources is becoming increasingly important.

The modern education paradigm also promotes interest in learning preferences to develop the necessary attitudes and skills of lifelong learning, especially in the context of the need to "learning to learn." The logic of lifelong learning assumes that students gain more motivation to learn if they know their strengths and weaknesses in the learning process. In turn, if teachers can respond to people's strengths and weaknesses, student achievements are likely to increase.

Learning to learn skills can be the basis for lifelong learning. Students become independent in their learning if they know their strengths and weaknesses. The adverse effects of reduced contact between lecturers and students with introducing new ICTs will be balanced by a more effective learning strategy that students can use outside the classroom.

Attempts have long been known to take the problem of academic achievement beyond simple solutions, such as the connection with intelligence or previous academic achievements (Childs-Kean et al., 2020; Cassidy, 2004; Pashler et al., 2008). One such concept used in determining the factors influencing the effectiveness of learning is learning style. Since learning styles were investigated in a massive amount of research, there are many definitions, theoretical positions, models, interpretations, and construction dimensions. For example, the review (Coffield et al., 2004) lists 71 models of learning styles with different applications – from pedagogy to commercial use for testing propensity to professions, particularly on-service training, the management or professional development courses and more.

At the same time, there is criticism of the very concept of learning styles (An and Carr, 2017; Newton, 2015; Wininger et al., 2019). The very idea of a variety of approaches to learning among students is usually not criticised. The concept of correlation between learning styles, teaching methods and academic performance is more often criticised. A large number of model ideas about learning styles is a natural consequence of extensive empirical research. This situation can be expected for any continually evolving concept. However, the level of ambiguity and discussion is so high that even the task of choosing the appropriate tool or model to use is burdensome.

Teachers in all fields are increasingly aware of the critical importance of understanding how people learn. It is equally important that any attempts to integrate learning style into educational programs are made from an informed position. According to (Coffield et al., 2004), the vast majority of models of learning styles can be divided into five groups. This distribution covers more than 50 different models. Each group is characterised by the presence of several well-developed and popular theories. Some of them, which are decisive in the distribution of five groups, are listed below.

1. Constitutionally-based learning styles and preferences including the four modalities: visual, auditory, kinaesthetic, tactile (Dunn and Dunn, 1992; Gregorc, 1984);
2. Cognitive structures which are reflected in learning styles (Riding, 2002);
3. Learning styles are one component of a relatively stable personality type (Apter, 2001; Jackson and Lawty-Jones, 1996; Myers and McCaulley, 1998);
4. Learning approaches, strategies, orientations and conceptions are considered instead of learning styles (Entwistle, 2018; Sternberg, 1999; Vermunt, 1996);
5. Flexibly stable learning preferences (Allinson and Hayes, 1996; Mayer, 1993; Herrmann, 1996; Honey and Mumford, 2000; Kolb, 2000).

Each group is based on different assumptions. Some theories are based on studies of brain function. Accordingly, specific nerve activity associated with learning can be detected in different areas of the brain. Other influential ideas come from established psychological theories. Learning styles are believed to be formed based on the fixed traits and intellectual abilities of individuals. Therefore, styles can be accurately identified and then reliably measured using psychological tests. Test results predict behaviour and learning achievements.

In contrast to the above models, other theories avoid all notions of individual features. Attention is focused on the contextual and situational nature of learning. Such models prefer to study the biography of an individual rather than styles or approaches.

Very popular are models that present learning styles as "flexibly stable". Previous learning experiences and other environmental factors may create preferences, approaches, or strategies rather than styles. Therefore, styles can vary from context to context or even from task to task. Sufficiently reliable tools for diagnosis and predictions can be created and used to improve student's learning level. In this approach, learning style is not a fixed feature but a diverse differential advantage in learning, which varies slightly from situation to situation. At the same time, there is some long-term stability in the learning style. Models of learning styles as flexibly stable preferences, which are usually well adapted for teaching natural and technical disciplines (Felder and Silverman, 1988; Felder and Spurlin, 2005), will be used in this paper. According to this approach, one should first understand the learning preferences of individual students and the preferred learning style of a whole student group (Alzain et al., 2018, 2016).

Previous research corroborated the existence of correlations between student learning styles and their preferences in choosing e-learning resources. The use of e-resources, which can be called sensitive to learning style, is widespread in natural sciences, such as chemistry, biology, physics, ecology, engineering (Derkach and Starova, 2017; Derkach, 2018, 2019; Nechypurenko et al., 2018, 2020a). This fact must be taken into account when organising training.

Regarding the course content changes, a clear and essential from a practical viewpoint is the introduction into the curriculum of data on environmental pollution of wild medicinal plants. In Ukraine, industrial pollution of rivers, soils, and consequently plants is a serious problem. By some estimates, about 25% of the drugs used worldwide are directly obtained from medicinal plants. In Ukraine, approximately 50% of the bulk medicinal herb feedstock are cultivated under controlled conditions. At the same time, the rest belongs to wild plants.

However, the number of certain types of medicinal plants is decreasing, and the natural reserves of some wild species are entirely or partially depleted. About 200 species are listed in the Red Book of Ukraine, and more than 70 are regionally rare (Minarchenko, 2014). Many wild medicinal plants have limited resources. More than 50% of them are significantly distributed but grow scattered or sporadically. Harvesting of such plants in natural places of growth is unprofitable. The shortage of plant raw materials is due to the ecological load, changing climatic conditions, and anthropogenic factors. In addition to reducing plants' natural habitat, damaged ecology also deteriorates their quality due to contamination with various pollutants.

In summary, the optimal organisation of the educational process ensures the acquisition by future professionals of the competencies necessary for the work and organisation of production and technology in a sustainable society. Optimisation of the educational process concerns both the methods and educational resources and the studied disciplines' content. Considering the learning styles inherent in individual students provides individualisation of education while increasing the effectiveness of learning.

This work aims to identify ways to modernise the educational environment of universities to implement the philosophy of sustainable development in the competence of future graduates of the Faculty of Natural Sciences. First, the prevailing learning styles of student groups majoring in chemistry and informatics will be determined. Then the acquired knowledge will be used in optimising teaching methods in studying ecological chemistry.

2 EXPERIMENTAL

2.1 General Scheme of Experiment

The central part of the experiments was performed at Kryvyi Rih State Pedagogical University (KSPU). Totally 61 persons, including ten male and 51 female, participated in the experiment. They were virtually all first- to fifth-year students of the Faculty of Natural Science of two admission years. They took undergraduate or graduate courses majoring in chemistry and informatics. Senior students studied the integrated course "Ecochemistry and Environmental Monitoring" in the 4th year of study. Junior students have not yet begun to study it.

The experiment consists of three stages. At first, the dominant learning styles were studied for all students who participated in the experiment at the KSPU. The variability of learning styles was studied depending on students' gender, age and study year. Based on the results of measuring the preferences of individuals, educational profiles were developed for student groups.

The course "Ecochemistry and Environmental Monitoring" consisted of 18 lecture hours and 72 hours of laboratory works. This course fruitfully links theoretical knowledge of chemistry and its practical application. It included three content modules devoted to various aspects of ecology. The second stage of the experiment aims to correct teaching methods for the module "Ecological chemistry of environmental objects". For this purpose, didactic materials have been developed that best meet the existing educational preferences of student groups.

At the next stage of the experiment, correcting the course content was proposed by including a new topic, "Ecological pollution of plants", in the module "Ecological chemistry of environmental objects". The new topic's content strengthens students' environmental competencies, expanding their knowledge to the food and pharmaceutical industries.

Some aspects of the new content were improved by one of the co-authors using the same experimental stages 1 and 2 at the Kyiv National University of Technology and Design (KNUTD). A total of 178 students majoring in industrial pharmacy at the Faculty of Chemical and Biopharmaceutical Technologies participated in the experiment to determine educational profiles.

Students from both universities specialised in related, albeit different areas of education. As is well known, educational benefits strongly correlate with the field of study. For this reason, the stylistic educational characteristics of students of both universities were analysed separately. In both cases, the sample size was limited by the available number of students because almost all students participated in the experiment.

Some environmentally-oriented educational elements were introduced in an analytical chemistry program at the bachelor's level and a pharmaceutical quality system curricula within a master's program at KNUTD. Accordingly, 164 undergraduate students and 14 masters took part in the testing of learning preferences. Such a change in the curricula forms a student understanding of the need to continuously acquire new knowledge about plant raw materials and continuously improve the production process.

The obtained results and research methods used at KNUTD are described in this article. They complement the experiment results at KSPU and can be further used to improve the course "Ecochemistry and Environmental Monitoring".

2.2 Index of Learning Style Instrument

The instrument, known as Index of Learning Style and developed by R. Felder and B. Soloman (thereinafter Felder-Soloman's model), was used to study students' learning preferences (Felder and Brent, 2016; Felder and Soloman, 2020). All respondents were interviewed to respond to 44 questions.

The instrument categorises individuals in line with their preferences in four complementary dimensions. These dimensions are as follows: perception – sensing (sns in a clipped form) or intuitive (int), information input – visual (vis) or verbal (vrb), data processing – active (act) or reflective (ref) and understanding of information – sequential (seq) or global (glo).

In other words, each of the four dimension consists of two opposite styles or a pair of style and anti-style. An 11-point scale scores them. The advantage of one of two opposite styles is estimated based on the distribution of 11 points between them. In this paper, the results related to preferred learning styles will be given percentages indicating the relative number of students in the sample with a particular style. Therefore, the number of students will always be 100% for a given style and anti-style pair.

2.3 Style-induced Preferences in Learning

Consider in detail aspects of the R. Felder and B. Soloman model's learning styles, namely the main characteristics of cognitive functions, if one of the styles prevails.

Sensing-type students prefer to learn the facts. They should solve problems using known methods. They do not like difficulties and surprises. So, they will be upset if they receive a question on educational material that has not been covered in detail in a lecture room. Sensing students are also attentive to detail, well-remembered, and do laboratory works, more practical and careful.

Intuitive students prefer theories and hypotheses, love innovation, and do not like repetition. They have a better understanding of new concepts and tend to feel more confident with abstractions and formulas. They work faster and more inventive (Felder and Silverman, 1988; Felder and Spurlin, 2005). Students with a pronounced sensing learning style do not like courses that are not relevant to reality. Intuitive students do not like instructional courses that require a lot of memorisation and tedious calculations.

The benefits of one or the other way of learning can be strong, medium or weak. Students should be able to act in both ways to be effective in teaching and solving problems. If they favour intuition too much, they may lose important details and make mistakes in calculations and lab work due to inattention. If they rely solely on sensing learning, they will reduce learning to cramming and repetition of known methods, refusing to live experiment and develop creative thinking (Felder and Soloman, 2020).

Sensing-type students remember and understand information better when they see how it relates to real life. When they study a discipline that contains much material in the form of theories and abstractions, difficulties may arise. The teacher should be given specific examples for each concept and methodology and show how these concepts are practically used to prevent obstacles in learning theoretical problems. Suppose the teacher does not provide sufficient specific data. In that case, sensing students should find it on their own or in a textbook, or other texts, or using a joint brainstorming session with their learning colleagues (Felder and Silverman, 1988; Felder and Spurlin, 2005).

Usually, intuitive type students take most lectures without problems. However, suppose such students find themselves in classes where they are primarily required to memorise and mechanically use formulas. In that case, they may have problems and boredom. Therefore, the teacher should be provided with interpretations and theories related to the facts studied. If this does not happen, students of intuitive type should try to find regular connections independently (Felder and Soloman, 2020).

Students who have a distinct visual learning style better remember what they see – pictures, diagrams, flowcharts, graphs, movies and visual demonstrations. Verbal students are more likely to receive information in the form of words – written and oral explanations. Both types absorb more when the information is presented both visually and verbally (Felder and Soloman, 2020).

Most classes use very little visual information: students mainly listen to lectures, read materials written on blackboard and textbooks, and manipulate materials. The facts indicate that most students are people with a visual type of perception. In other words, they do not get as much as they could if the visual presentation of data were used more in the class (Felder and Silverman, 1988; Felder and Spurlin, 2005).

Suppose the student has a visual type of perception. In that case, he/she must independently find diagrams, sketches, diagrams, photographs, graphs, or any other visual representation of course materials, which is predominantly verbal. References to videos, videos of the course will be helpful. Students should use maps or flowcharts. Such materials depict critical points of a theme in the middle of squares or other figures, with demonstrations of connections between concepts (in the form of a line with arrows between blocks) (Felder and Silverman, 1988; Felder and Spurlin, 2005). It is helpful for students of the visual type to use colour markings of records. Each colour has its meaning in such markings, highlighting concepts related to the same topic, class, type, etc. (Felder and Soloman, 2020).

Students of verbal type should write short summaries or translations, of course, materials in their own words. Group work can be beneficial to them. They understand the material better by listening to classmates' explanations and learning even more when explaining the content to others (Felder and Silverman, 1988; Felder and Spurlin, 2005).

Students who have the advantage of an active learning style can better understand and acquire new knowledge by doing something with them. Reflective students should first calmly reflect on the information received and then begin working with it (Felder and Silverman, 1988; Felder and Spurlin, 2005).

It is desired to have a balance of both styles. If the student always does and then thinks, at first, he or she may take up the case too hastily, which will create problems. If he spends too much time thinking, he can never do anything about it.

As a rule, active students are more comfortable working in a group than reflective students who prefer to study alone. Attending lectures without any movement and physical activity, apart from giving notes, is not easy for both types, but especially tricky for active students (Felder and Soloman, 2020).

Suppose there is little classroom time when discussing discipline or discussing it together. In that case, students with an active type of perception should make up for that. To do this, they need to prepare for a class together with a group of friends to take turns explaining topics to each other. It is helpful to imagine that they can be asked the next presentation and represent how they will respond (Felder and Silverman, 1988; Felder and Spurlin, 2005).

When students have a little time in the lecture room to reflect on new knowledge, persons with an intuitive perception should try to make up for the lack of that. To do this, they need to read and memorise the educational material and stop from time to time to repeat what they have read, think about possible questions and apply their knowledge. It is also helpful for them to write small summaries based on what they have read or taken notes in the audience, presenting the material in their own words. Such an approach requires additional time but will allow better study of information (Felder and Soloman, 2020).

Students with a predominant sequential learning style gain understanding through successive steps, each of which is a logical continuation of the previous one. Global-type students tend to learn giant leaps, gathering information almost haphazardly and then suddenly grasping the essence (Felder and Soloman, 2020).

Students with sequential perceptions tend to follow a logical step-by-step search. Students with global perceptions can solve problems quickly and put the pieces together once they have understood the big picture (Felder and Silverman, 1988; Felder and Spurlin, 2005).

Many people may mistakenly qualify as "global" because everyone felt astonished by the "illumination" (Felder and Soloman, 2020). However, what makes the perception global or sequential happens before the outbreak. Students with a very pronounced global perception who cannot think sequentially may experience severe difficulties until they understand the overall picture (Felder and Silverman, 1988; Felder and Spurlin, 2005). Even when received, they may have a vague idea of the details of the subject. Simultaneously, sequential students may know a great deal about specific aspects of the subject under study but not understand how they relate to its other components or other matters (Felder and Soloman, 2020).

Most courses in higher education are taught sequentially. Suppose a student has a sequential type of perception. Suppose also a teacher moves from one topic to another and misses the logical steps. In that case, it may be difficult for the student to keep track of his or her reflections and remember something. One needs to complete the missing steps with the teacher's answers or yourself, referring to the directories. Students should logically arrange the lecture material. To develop global thinking, one must try to relate each new topic to one studied before. The more a student does this, the deeper the problem will be understanding (Felder and Silverman, 1988; Felder and Spurlin, 2005)].

Suppose students have a global type of learning style. In that case, it will be useful for them to understand their need for a general picture of the subject under study before mastering the details. If a teacher starts a new topic without explaining how it relates to what has been learned before, it can cause problems. However, there are steps a student can take to get a total picture faster (Felder and Soloman, 2020).

Before beginning the first paragraph of the next section of the text, a student with a global learning style needs to review the section completely to understand a general idea. Initially, this will take extra time and subsequently avoid multiple revisions of individual parts (Felder and Soloman, 2020). Instead of spending time reviewing each subject for a short time each day, it may be more beneficial for such students to study topics in large blocks (Felder and Silverman, 1988; Felder and Spurlin, 2005).

Students of this type should try to relate the subject under study to what they already know. For example, they can ask a teacher to help them see the links or find them in the additional literature independently. At one time, a global student suddenly understands new material and understands its relation to other topics or disciplines. Then, he/she will be able to apply new knowledge very effectively. The student can use acquired information in a particular way that most sequential students do not dream of (Felder and Soloman, 2020).

2.4 Structure of Ecological Chemistry Course

Ecology is a scientific matrix on which the sustainable development of society is built. Sustainable development, in essence, is the inclusion of environmental knowledge in development activities in general. The course of ecological chemistry continues the cycle of chemical disciplines focusing on analysing chemical processes and objects in nature. Mastering the course will contribute to the formation of professional competencies of the future chemist, teacher of chemistry and ecology, or laboratory assistant of chemical-ecological laboratories.

The task of the course of ecological chemistry is to provide students with knowledge about: a) the chemical composition of natural objects; b) natural processes that occur with the participation of natural compounds in the presence of pollutants; c) systems of monitoring control over the condition of natural objects; d) indicators that determine the quality of the environment; e) features of chemical control of natural objects. The structure of the discipline "Ecochemistry and Environmental Monitoring" is given in table 1. The content of the discipline consists of three modules. One of the four topics of module 2, namely the topic "Environmental chemistry of the lithosphere", was chosen for the study to optimise teaching methods and tools following student groups' educational preferences.

Table 1: Structure of discipline "Ecochemistry and Environmental Monitoring" by topics and hours.

Name of topics	Total	Lectures	Labs	Independent work
Module 1. Introduction to a special course				
1.1 Monitoring & ecochemistry as environmental sciences	7	2	–	5
1.2 Human habitat	15	1	10	4
1.3 Chemical elements of the environment	8	1	4	3
Module 1 subtotal (hours)	30	4	14	12
Module 2. Ecological chemistry of natural objects				
2.1 Scientific aspects of ecological chemistry	14	–	–	14
2.2 Ecology of the atmosphere	30	2	14	14
2.3 Ecological chemistry of the hydrosphere	22	2	6	14
2.4 Ecological chemistry of the lithosphere	24	4	6	14
Module 2 subtotal (hours)	90	8	26	56
Module 3. Monitoring of natural objects				
3.1 Scientific bases of environmental monitoring	15	1	–	14
3.2 Atmospheric monitoring (air and gas mixtures)	24	2	8	14
3.3 Hydrosphere monitoring	24	2	12	10
3.4 Lithosphere monitoring	27	1	12	14
Module 3 subtotal (hours)	90	6	32	52
Total (hours/credits)	**210/7**	**18**	**72**	**120**

2.5 Algorithm of e-Resource Selection

To select educational resources according to students' educational preferences, we used the approach firstly described in (Baldiris et al., 2009). We determined students' preferences with different learning styles for certain types of ICT and e-resources used in the training of students of the Faculty of Natural Sciences. Individual e-resources were evaluated by questioning teachers and students. The assessment was made according to the so-called advantage indicator, determined on a 3-point scale. Points mean:

0 – an indifferent attitude to a resource because the respondent does not believe that this resource can contribute to the learning process;

1 – good attitude, the student considers it appropriate to work with this e-resource but does not give it an advantage over others;

2 – very good attitude; the student likes to learn with this type of resource and prefers it to other resources. The respondent also considers it very important for teaching that the teacher offers e-resources of this type.

According to the student survey results, the average scores of resource assessment were determined for students with different learning preferences. The results show how the type of e-resource is consistent with the type of student learning style. Such assessments became the basis for optimising the choice of teaching materials by the teacher. According to the teacher survey results, tables of expert evaluation of the feasibility of using e-resources in teaching specific topics of various disciplines at the Faculty of Natural Sciences were created.

In the presence of such evaluation data, the procedure for optimising the choice of resources to work in a particular student group can be reduced to the following steps:

1. Defining the types of student learning styles as a combination of four aspects (act / ref, sen / int, vis / vrb, seq / glo). Analysis of the group's composition, construction of its average profile or division into subgroups of students with similar learning preferences.
2. Compilation of a list of e-resources required for teaching a specific topic, based on a table of expert evaluation of the module content.
3. Calculation of the specific indicator for each allocated e-resource as a quantitative measure to justify the feasibility of using the resource in the classroom for groups with a particular combination of learning styles.

An example of the application of the described technique is given in (Derkach, 2018). An approach that implies using several types of e-resources for main learning elements was applied for further work in the group. It was considered that the style of teaching and the use of e-resources might run counter to the preferences of students, encouraging them to grow in less developed areas. However, the level of discomfort for students should not be too great. Therefore, we used e-resources that had an average score of ≥ 1. Duplication of information and inappropriate use of class time was not allowed.

2.6 Methods of Plant Chemistry Study

As argued in previous sections, one of the priorities among teaching methods is to teach sensitive students. It is favourable for them to create an environment where the material's presentation is based on real-life examples with specific information or indicators and their comparison. This feature was one of the arguments favouring the introduction of an in-depth study of the influence of the environment on plant chemistry in the course of ecological chemistry.

The content of metallic and non-metallic impurities in plants and the content of biologically active substances, from a practical viewpoint, is most important for medicinal plants. These plants are the raw material base for the pharmaceutical industry. Besides, they are widely used in the food industry, like spices or dietary supplements.

Plants always contain elemental impurities. Some chemical elements in plants, known as essential ones, take part in biochemical processes. In contrast, others do not contribute to plant development and are the product of plants' interaction with the environment (Kabata-Pendias, 2011). The contents of elemental impurities and biologically active substances are formed under the environment's influence (Derkach and Starikova, 2019). At optimal concentrations, the essential elements are helpful while they can become toxic in excess.

On the contrary, a plant poorly develops in deficiency of essential elements. In the meanwhile, the content of essential microelements is often not controlled in herbal medicines. Both essential and non-essential elements can be toxic to the consumers of herbs. Some non-essential metals (As, Cd, Pb and Hg) are very harmful (Chizzola, 2012; Locatelli et al., 2014).

Accordingly, the potential presence of toxic metals and the variability of biologically active substances content largely determines the quality, effectiveness and safety of medicinal plants and herbal medicines (Derkach and Starikova, 2019; Derkach and Khomenko, 2018a). Knowledge of the problems of plants, in general, and medicinal plants, in particular, will significantly strengthen the environmental competence of future chemists. Some of the results obtained, which are essential for the formation of environmental competence, will be presented in the following sections.

The primary experimental method for studying the elemental composition of plants was flame atomic absorption (FAAS). Biologically active substances were investigated by high-performance liquid chromatography (HPLC). The used sample preparation methods, equipment and details of experiments are given elsewhere (Derkach and Starikova, 2019; Derkach and Khomenko, 2018b).

3 RESULTS

3.1 Preferences in Learning Styles

The results obtained in the study of learning preferences are shown in Fig. 1 as the average for all interviewed students. A significant difference was observed in three dimensions: sns (65.7%) / int (34.3%); vis (64.2%) / vrb (33.2%) and act (59.5%) / ref (40.5%). No essential difference was found in the fourth dimension of seq (50.1%) / glo (49.9%). In other words, a style prevails over its anti-style in three dimensions. In the fourth dimension, a balance is observed between style and anti-style.

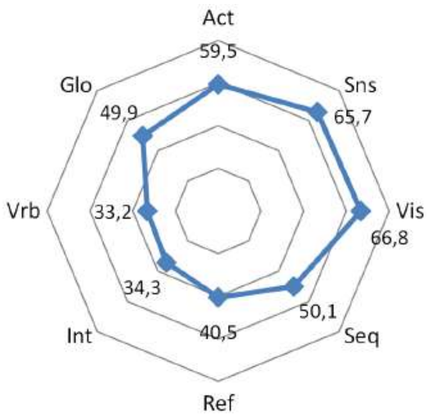

Figure 1: Preferences in learning styles for students of the Faculty of Natural Sciences of KSPU, the speciality 014 Secondary education (chemistry & informatics).

Typically, learning style is a relatively stable and weakly variable characteristic of a person formed under the influence of its psychological and physiological characteristics. For example, it was shown in (Derkach and Starova, 2017) that it is weakly dependent on the year of study for first- to fourth-year undergraduate students.

The opposite view is that dominant learning styles can change under the influence of external circumstances. Such influencing factors may include the field of study and type of material being studied, delivery mode, the age of an individual, motivation and educational level, etc.

It is also commonly believed that learning styles are not sensitive to the student's gender but may vary significantly between students in different fields of study. However, the question of the stability of learning styles and their dependence on students' gender and age can still be considered debatable. The results obtained in the paper allow us to evaluate the influence of the above factors. For this reason, the results of testing the learning styles were divided into groups by gender (figure 2).

Comparing the results of the two studied groups "boys" and "girls", we can see that respondents-boys and respondents-girls have a difference between the two dimensions: "boys" – vis (75.8%) / vrb (24.2%), seq (59.1%) / glo (40.9%); "girls" – vis (62.6%) / vrb (34.0%); seq (46.9%) / glo (53.1%).

In two other characteristics, the difference is almost imperceptible: "boys" – sns (68.2%) / int (31.8%), act (60.6%) / ref (39.4%); "girls" – sns (65.4%) / int (34.6%) and act (59.8%) / ref (40.2%).

Also, testing all students' learning styles was divided into groups by age (figure 3). Comparing the results for ages of 17–20 and 20+ years, we concluded that these groups' respondents had only minor differences. For 17–20 years, the preferred styles are as follows: sns (64.1%) / int (35.9%), vis (66.2%) / vrb (33.8%), act (59.3%) / ref (40.7%), seq (51.1%) / glo (48.9%). For 21+ years, sns (68.2%) / int (31.8%), vis (61.0%) / vrb (39.0%), act (59.7%) / ref (40.3%), seq (48.7%) / glo (51.3%).

In our opinion, there is a slight difference in the respondents' learning styles because all the respondents study in the same speciality. The existing preferences among students-pharmacists of KNUTD compared with the average indicators of students-chemists of KSPU are given in figure 4. Learning preferences are shown for undergraduate and separately for graduate students of KNUTD.

The predominance of the act, vis and sns styles is maintained for all groups of students. KSPU students are balanced in measuring seq-glo. At the same time, pharmacists show a pronounced advantage in favour of a sequential style. The most significant difference is between undergraduate students of KNUTD and all other groups. That is, the difference between students of KSPU and masters of KNUTD is significantly reduced. The measurement of seq-glo is an exception because the existing advantage of a sequential style among pharmacists does not change over years of study.

3.2 Teaching Ecological Chemistry of the Lithosphere

Considering the obtained profiles of educational advantages in groups, we have prepared a didactic material on the topic "Ecological chemistry of the lithosphere" of the content module "Ecological chemistry of environmental objects". Most students in the group are those who study visually, sensitively, actively, and sequentially. That is why we used the methods, forms, and e-resources that are well percept by them in the lecture. Example:

- a large amount of multimedia presentation data was used for visual perception of information during the lecture;
- for sensing data processing, lecture information was provided based on life stories and situations;
- to attract an active component of the training types, several problematic situations on this topic were created. Students worked in small groups for several minutes over their decision;
- a link between current material and everyday life was demonstrated for the sequential component.

For the lecture, information on the following processes was elaborated: soil formation, weathering and its varieties, leaching, gouging, salting and others, and learning about the participation of living organisms in soil formation.

Submission of material on the lithosphere's fundamental processes was also adapted to students' prevailing stylistic characteristics: visual, sensing, active and sequential, but other techniques have already been used. Example:

- a multimedia presentation with various diagrams and photographs illustrating the content of the theme was used for visual stylistic characteristics during the class;
- for the sensing style, the information of the lecture was related to the environment, which is directly an integral part of human life;
- for the active component, lectures specifically made mistakes in the content and provided an opportunity for students in small groups (2–3 people) to consider where the inaccuracy was made;
- for a sequential component, the connection between current material and everyday life was demonstrated.

During the laboratory session, we formed practical knowledge about the soil composition and some of its indicators. For this purpose, the following methods were applied:

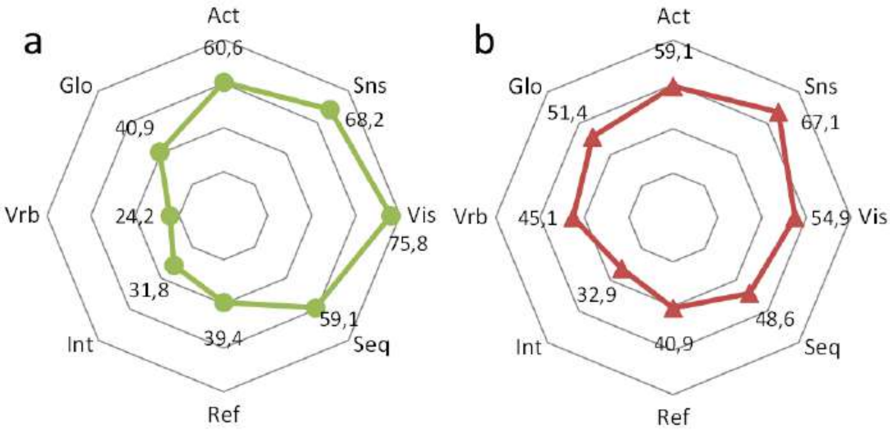

Figure 2: Preferences in learning styles for male (a) and female (b) students.

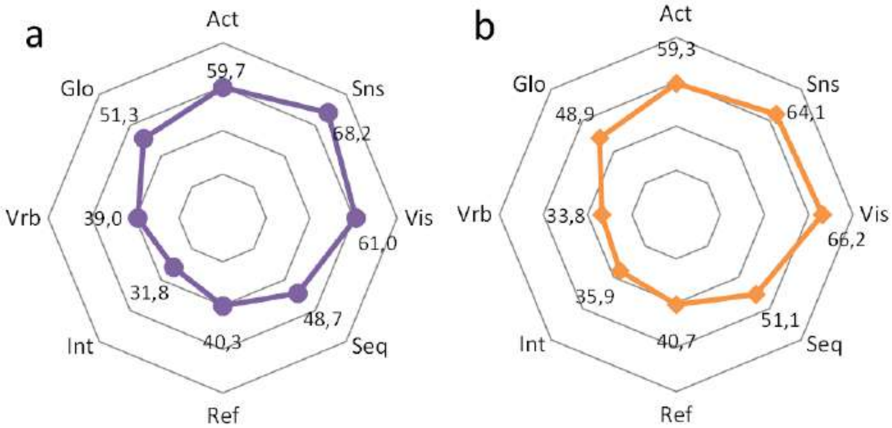

Figure 3: Preferences in learning styles for students of 17–20 (a) and 21+ (b) years old.

- illustrations of the mechanical composition of the soil, video of bean growth, and instructions for planting it in the soil were used simultaneously with the parallel text that described these processes to learn by visual style during the laboratory work;
- for the sensing style, the information related to the fertile surface layer of the lithosphere, which is directly connected with human life, was provided. Students were asked to find signs that determine the quality of the soil and its use in human activity;
- an analysis of soils in which beans grew was used for the students with active style in the laboratory. Students worked in small groups analysing soils.

The content of students' independent work included tasks that, in our opinion, are intended to help develop a global, reflective, verbal, and intuitive styles of learning activity.

Here are examples of the tasks of students' independent work. Students were invited to do the following task to develop a global characteristic of the seq/glo pair of learning styles. "Use the guides, the Internet, and other recommended sources to learn about the content of the ecological chemistry of the lithosphere. Determine the importance of chemical processes in soils for the formation of biogeochemical cycles of chemical elements and their substances in the nature of our planet".

To satisfy the reflective learning style in the act/ref dimension, we asked students to do the following. "Using lecture notes, read the study material, occasionally pausing to repeat what you have read. Write small abstracts based on what you have read. What is the main source of pollution of the lithosphere? Describe the main components of the emissions from such a source and their influence on the fertile soil layer's chemical composition. What are some ways we can deal with the primary and re-contamination of key areas?"

To satisfy the requirements of a verbal style in the vis/vrb pair, we asked students to do the following task: "Using the above text, make a diagram of the

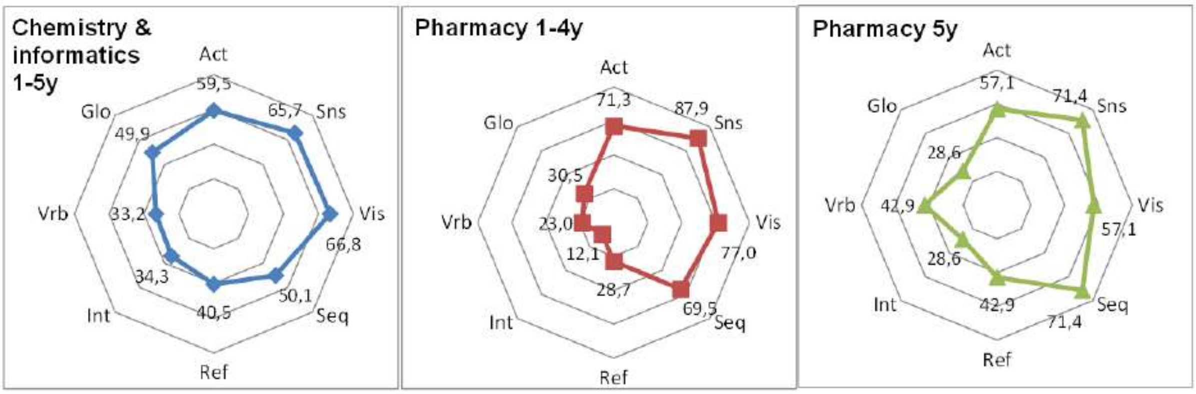

Figure 4: Learning styles of 1-5 years students majoring in chemistry & informatics at KSPU compared to styles of 1–4 years undergraduate and 5-year master students of industrial pharmacy at KNUTD.

biogeochemical cycle of carbon.

Carbon in nature:

The chain of carbon atoms is the basis of all organic matter: proteins, fats, carbohydrates and other compounds that are necessary for the life of all living organisms. The carboniferous circulation between wild and inanimate nature occurs at high speed. The main inorganic compounds of carbon are its oxides (CO_2 and CO) and carbonate, making up carbonate rocks. The most mobile carbon compound in the atmosphere, which plays a significant role in the cycle, is carbon dioxide (CO_2).

Carbon's central reserve is concentrated in carboniferous rocks (carbonates, dolomite, etc.) at the bottom of the ocean and in the Earth's crust, as well as fossil fuels. The carbon reserve in the atmosphere is much smaller. However, it plays a significant role in the cycle due to its mobility. As a result of the relatively small reserves in the atmosphere, the carbon cycle is more vulnerable than the nitrogen cycle.

Recently, the atmosphere's carbon dioxide content has been steadily increasing, indicating that the equilibrium processes in the biosphere are disturbed. The reason is human economic activity: high carbon dioxide emissions from burning fossil fuels, reducing forest area, pollution of the oceans. As a result, photosynthesis intensity and carbon dioxide binding decrease. Increasing carbon dioxide content is the leading cause of the greenhouse effect and an increase in the average temperature on the planet."

We proposed that students do the following task to develop an intuitive style in the subsystem sen/int. "Tailings cause a large amount of dust under the influence of wind flows, which leads to the pollution of atmospheric air and its deposition in large areas of land. Suggest a plan for minimising dust generation".

Thereby in the course of the study, we started to introduce students to different forms of work. These forms involve using the different cognitive functions and therefore contribute to the development of their balance. In turn, the latter allows a person to be flexible in the unrestrained development of technological progress, be open to different ways of receiving information and perceiving it without resistance and tension. As a whole, students evaluated the completed tasks at a high level, which indicates that the student's perception of new tasks is positively fulfilled, without sabotage.

3.3 Teaching Plant Pollution

As shown in the previous section, the sensitive perception of information is characteristic of most KSPU and KNUTD students. Such students perceive the theoretical part more effectively if they can establish a connection between theory and real-life facts. It seems appropriate to strengthen the course of ecological chemistry with new topics, which are essentially based on the consideration of numerous real-life examples. The environmental pollution of plants by human economic activity products looks promising because its teaching can include many real examples. On the one hand, such topics will be well perceived by students with the revealed educational preferences. On the other hand, they will strengthen the environmental component in the education of future professionals. Accordingly, if the previous section considers procedures, methods and approaches to learning ecological chemistry, this section considers the proposed changes in the discipline content.

Previously measured elemental and chemical composition of several widespread medicinal plants growing in different regions of Ukraine (Derkach and Starikova, 2019; Derkach and Khomenko, 2018a,b) were used as environmental education elements in the teaching of analytical chemistry and pharmaceutical quality system. Elemental composition compared to the available recommendations for the content of metals and metalloids in plant foods, medicines, dietary supplements, spices, etc. Authorised organisations use different characteristics to determine the limits of element intake in the human body. Virtually all elements, except for particularly toxic ones (As, Cd, Pb, Hg), can play a dual role and become toxic in a particular concentration. As a rule, there is a concentration interval of optimal daily human consumption of a particular element. Various norms regulate either the recommended dose of the element (often per 1 kg of human weight) or the maximum allowable intake.

Two aggregated characteristic exposures, entitled Level of Optimal Consumption (LOC) and Upper Limit of Safe Consumption (ULSC), are constructed based on the universally recognised norms (Derkach and Khomenko, 2018a; WHO, 2007; EC, 2006; www.atsdr.cdc.gov, 2016; Rubio et al., 2018). Ranges of some element concentrations were measured in a few popular medicinal plans (St Jon's wort, chamomile, nettle and sage). The measured concentrations were compared with the LOC and ULSC values, as shown in table 2. The ULSC and LOC ratios to the maximal measured concentrations respectively estimate maximum allowable and safe limits of daily intakes of the most contaminated studied herbs from the viewpoint of possible side effect of the microelements (table 2).

Figure 5 illustrates the variability of biologically active substances in medicinal plants.

As an example, the HPLC were shown for herbal preparations "St. John's wort herb", prepared by four different suppliers and purchased in Kyiv pharmacies. As an example, the HPLC were shown for herbal preparations "St. John's wort herb", prepared by four different suppliers and purchased in Kyiv pharmacies. As is seen, the concentrations of flavonoid rutin and hypericin are the highest in samples of supplier 4. In contrast, the herbs of supplier 3 are most enriched in hyperforin. Herbs of suppliers 1 and 2 are characterised by the highest concentrations of quercetin and hyperoside, respectively. Among flavonoids, the observed concentration fluctuations are relatively moderate for quercetin and hyperoside. For these compounds, the maximum-to-minimum concentration ratios are 1.45 and 1.87, respectively. The variation of rutin concentration is the highest, 13.8 for the maximum-to-minimum ratio. Amid flavonoid fluctuations, the instability of antidepressants (hyperforin and hypericin) appears to be moderate – 3.11 and 4.7 for these compounds, respectively.

4 DISCUSSION

4.1 Learning Preferences in Different Fields of Studies

The study results have shown that the existing preferences in learning styles among students majoring in chemistry and informatics generally persist throughout their studies. They are relatively weakly dependent on gender and age. The students demonstrate solid preferences for sensing, visual and active learning style. In the dimension of seq-glo styles, an approximate balance is observed.

The question arises as to whether the invented behaviour patterns are universal or inherent only to a particular speciality. Learning styles were determined for students of different specialities at the Faculty of Natural Sciences (figure 6) to compare with students majoring in chemistry and informatics (figure 1).

A difference in almost all style dimensions is observed between specialities. For example, most ecology students prefer reflective style (52.7% ref vs 4.3% act). In contrast, all other specialities prefer active learning (51.5–61.6% of active students vs 38.4–40.5% reflective). A discrepancy in the sen-int dimension almost reaches 11% – from 61.1% for physiologists to 71% for chemists. In the vis-vrb dimension, it exceeds 16%. Students majoring in biology and physiology are the most balanced, while visual learning dominates in all other specialities. The speciality "ecology" and "biology + physiology" demonstrate a clear preference for sequential style. In contrast, students of biology + chemistry and chemistry + informatics specialities are well-balanced in this dimension.

Similar to the results obtained, there is much evidence in the scientific literature that students in different study fields often demonstrate different learning styles (Derkach and Starova, 2017; Derkach, 2018; Sahragard et al., 2016). The origin of different learning styles in different environments is not finally evident yet. Instead, one may suppose that learning styles are educational strategies that characterise the individual's actions in response to a particular learning situation. Thus, the learning styles or individually-unique ways of educational activity by their very nature may depend directly on the educational technology used, including the teaching methods, types of educational resources, teacher position, status educational institution, etc.

So, the definition of learning styles as flexibly stable preferences in information processing, instructional technologies, and learning strategies fits the obtained results well. Accordingly, the development

Table 2: LOC and ULSC ranges in comparison with the measured concentration range and safe daily intakes.

Element	**Measured concentrations, μg/g**	**ULSC, mg**	**LOC, mg**	**Maximum allowable intake, g/day**	**Safe intake, g/day**
Al	No data	0.5-10	10		
As (in inorganics)	No data	0.021-0.3	0.02		
B	No data	6.2-20	14		
Ba	No data	4.0-14	14		
Be	No data	0.14	0.14		
Ca	No data	2500	1000		
Cd	0.2-0.9	0.02-0.07	0.007	22	8
Co	0.08-0.4		0.02-0.04	1500	50
Cr	0.2-2.0	0.25-21 (CrIII)	0.002-0.003 (CrVI)	125	1
Cu	5.0-12	10.0-12	0.7-0.9	833	58
Fe	25-120	9.7-58.8	8.0-18	81	67
Hg	No data	0.35	0.014		
K	7500-9900		4700		475
Mg	1000-1600	350-2500	310-420	219	194
Mn	40-150	2.0-11	0.35-2.3	13	2
Mo	No data	0.03-2	0.045		
Na	110-160		1500	0	9375
Ni	0.8-2.8	0.2-1		71	0
Pb	0.1-6.2	0.1-0.25	0.14	16	23
Sb	No data	30			
Se	No data	0.3-0.4	0.055-0.35		
Sr	No data	42			
V	No data		0.7		
Zn	19-34	21-50	8.0-21	1	235

of didactic materials based on the identified learning profiles seems appropriate for teaching ecological chemistry.

4.2 Conflict of Styles

Lecturers have their advantages of learning styles (Rahimi et al., 2017). Most lecture courses are aimed at a small number of people who can perceive and process information intuitively, verbally, reflectively and sequentially. Such a situation creates a disadvantage for many students.

Lab work, being inherently sensing, visual, and active, could offset some of the imbalance. However, most laboratory work involves, first and foremost, mechanical exercises. They illustrate only a small part of the concepts discussed at the lectures and rarely provide a robust understanding or development of skills. Thus, sensing, visual, active and global students rarely meet their educational needs when studying at higher education institutions.

The discrepancy between teaching and learning styles has several serious implications. In this case, the students feel that communication is taking place in an unknown foreign language.

These problems can be minimised, and education quality can be significantly improved if teachers consider the particularities of student preferences in teaching styles (Richardson, 2011; Franzoni and Assar, 2009).

It is challenging to create the conditions for the presentation of information that satisfies all possible student learning styles in one audience. There are different approaches to solving this problem.

The works we have done earlier describe the methodology of choosing methods, forms, and teaching aids, taking into account students' peculiarities of learning styles of different specialities (Derkach, 2019; Derkach and Starova, 2017; Derkach, 2018). He has a right to life and another approach that involves applying the techniques of presenting information conveniently to each style for a while.

The development of all cognitive styles is beneficial for students. Therefore, seeking to strike a bal-

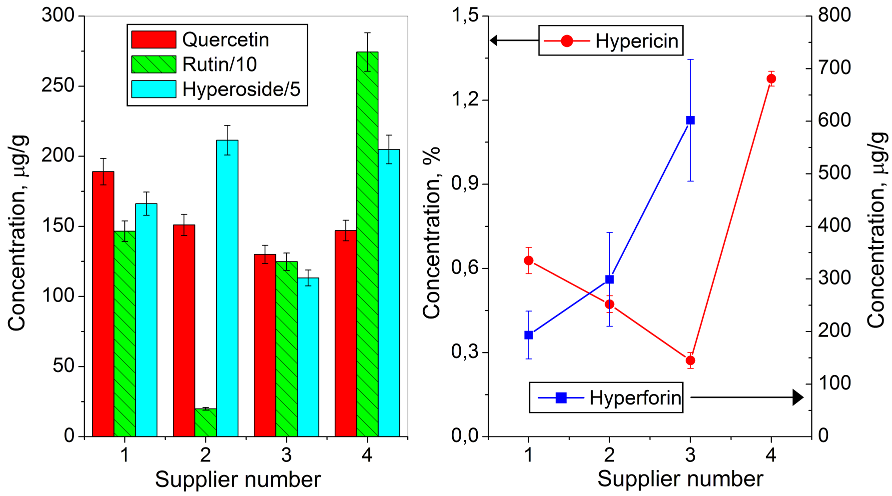

Figure 5: Concentrations of biologically active compounds (hypericin, hyperforin and flavonoids) in herbal medicines St John's wort of different suppliers.

ance for everyone in the learning process can be helpful. Then students will have natural learning activities available to them and create conditions for the development of other learning styles. Such a situation can promote active learning and a positive attitude towards it and lead to the strengthening of less developed abilities (Mayer, 1993).

When developing a global teaching style, it is better to study the material using visual techniques. These techniques should allow students to offer a generalised conclusion from their analysis. To do this, you should first show the schematics of the links of the elements for study, experiments, results, and then allow students to reach the provisions of specific theories independently.

When developing a reflective teaching style, teachers sometimes need to stop during the lecture to allow the audience to think and formulate questions. You should also schedule small group problem-solving sessions. Then group students will have a chance to spend one or several minutes solving any of the many different issues and problems. Some examples of such problems are as follows. "Start solving this problem", "What is wrong with what I wrote on the board?", "Suppose you enter a lab, check the measurement results, and find that the formula we just derived gives incorrect results. How many possible explanations can you come up with?"

Also, to develop a global teaching style, it is necessary to demonstrate the logical connection of particular topics. It is also essential to show the interaction between current material and other topics of the same discipline, other courses and daily life. Encouraging or engaging in self-help in homework is essential. Students who participate in collective learning, both in and out of the classroom, receive better grades and show tremendous enthusiasm (Mayer, 1993).

4.3 Environmentally-induced Variation of the Chemical Composition of Medicinal Plants

The data in the previous section provide several examples of the impact of the environment on the elemental and chemical composition of a number of medicinal plants. The introduction of this type of material in the curriculum creates a favourable environment for sensitive students. Among undergraduate pharmacy students, up to 88% of students have a sensitive learning style.

These examples clearly illustrate the fact of variation in plant composition depending on growing conditions. For example, the content of some biologically active substances, which determine the effectiveness of herbal medicines, varies by 1.5–14 times. Accordingly, the quality of herbal medicines of various origins varies within these broad limits. It should be emphasised that these examples are herbal medicines that are purchased legally in pharmacies. The obvious conclusion is that the existing quality control system does not fully ensure consistent and uniform herbal medicine quality.

The analysis of the given data on the elemental composition also shows high variability in plants' composition in different areas. The content of toxic impurities and excessive contamination with essential elements that are not toxic in moderation directly affects herbal medicines' safety. Besides, the presence of ions of some metals in plants can affect their ef-

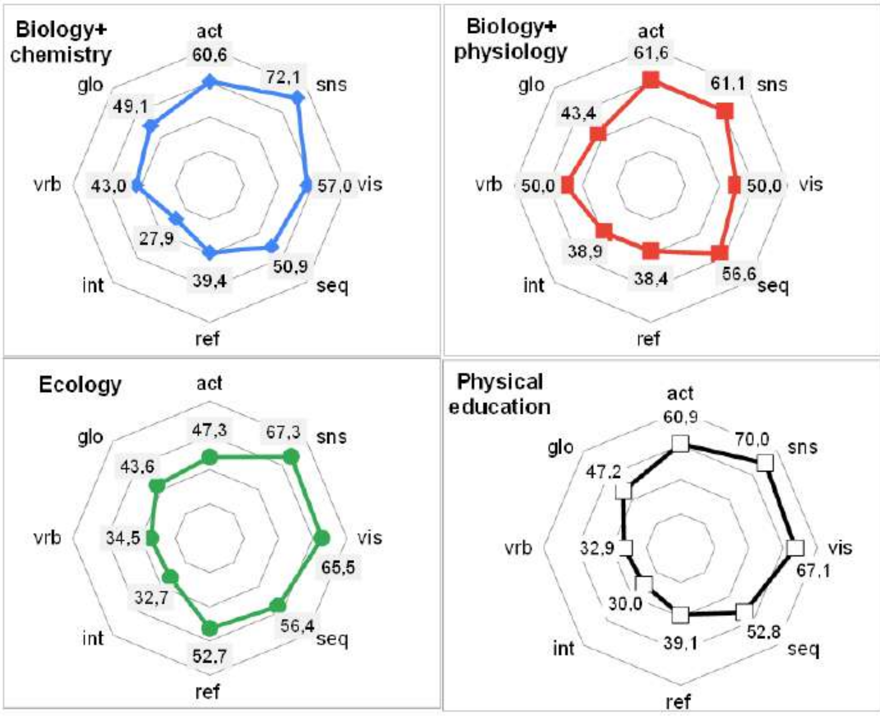

Figure 6: Learning styles of 1–4 years KSPU students majoring in biology & chemistry, biology & physiology, ecology and physical education.

fectiveness. Many free ions can form metal-organic complexes, bind biologically active substances into complexes and reduce their activity.

Draws attention to the fact that the plants available in pharmacies in terms of the content of the most toxic metals generally meet the standards (table 2). The most unfavourable situation is concerning cadmium. Daily safe internal consumption of the most contaminated grass should not exceed 8 g. Even worse is the consumption of plants with high *Cr* and *Mn* contents; no more than 1 and 2 g, respectively, are safe for daily intake.

As is known, Ukraine has rich deposits of manganese (about 10% of world resources). The explored reserves of mining companies are 140 million tons or about 21% of world reserves (Sun et al., 2020). The country is a prominent producer of manganese ore. The primary deposits are concentrated in the Dnipropetrovsk region. The chain of manganese circulation, from its extraction, further processing and end-use in various industries, is illustrated in figure 7. The initial data for illustration are taken from (Sun et al., 2020). According to the results of 2017, the total manganese in the world is 23.9 million tons.

The source of manganese supply is manganese and iron ores, as well as manganese-containing scrap. When processing ore and scrap, they are converted into various intermediate products by smelting, electrolysis or other technological processes. They are various ferroalloys and other manganese compounds. As a final consumption, manganese is used to produce steel and aluminium alloys, various galvanic cells, fertilisers, animal feed components, and other products.

Sooner or later, the lifespan of manganese products expires and such products are discarded. If the spent elements are collected, their secondary use begins in the form of scrap. Unfortunately, most of the discarded products are not efficiently collected and processed. They are classified as waste. Currently, there are almost no well-established systems (except for steel metallurgy) of manganese regeneration.

Accordingly, waste manganese products and emissions from the metallurgical and mining industries are environmental pollution sources. The scale of pollution from human activities is huge. As already mentioned, the primary manganese deposits, ferroalloy and metallurgical plants are concentrated in the Dnipropetrovsk region. Accordingly, the impact of these enterprises on the environment focuses on this region. Simultaneously, heavy manganese pollution of small rivers is registered even in the Ternopil region (Prokopchuk and Hrubinko, 2016). This paper presents data on manganese contamination of

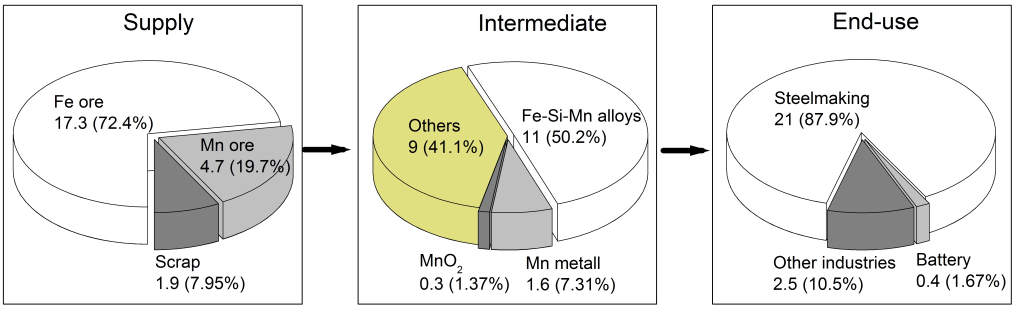

Figure 7: Supply and intermediate products and end-use of *Mn* in the world (million ton and %).

medicinal plants collected in four different regions of Ukraine. For example, manganese and iron are known to be antagonists in plants (Alejandro et al., 2020; Zaitsev et al., 2020). In many countries, iron concentration in tissues of most plants is usually higher than *Mn* content. Ukraine is an exception in this sense, as the concentration of manganese has been shown to exceed typically iron concentration (Derkach and Khomenko, 2018a,b). Obviously, the source of such pollution is the spread of manganese waste.

Mn is the fifth most abundant metal on the Earth. *Mn* does not occur naturally in a pure state (Schmidt and Husted, 2019; Huang and Zhang, 2020). It exists in both inorganic and organic compounds — the inorganic form being the most common. However, *Mn* also exists in organic forms, particularly as an additive to fertilisers and fuels. In principle, *Mn* can occur in 11 different oxidation states, varying from -3 to +7 because of 7 electrons in the outer electron shell. In living tissue, *Mn* has been found as Mn^{2+}, Mn^{3+}, and possibly as Mn^{4+}. Higher oxides and other complexes of *Mn* at lower oxidation states are not observed in biological materials. This element is essential for normal biochemical and physiological functions in plants and serves as a co-factor for some enzymes.

The most common toxicity is manganese in a professional environment. However, there are known cases of adverse health effects of this element due to environmental impact. Poisoning by this element is referred to as manganism (Lange and Condelo III, 2016). The suggested dietary intake of *Mn* is about 2 mg/day (table 2). Organ systems most affected are the liver, heart and nervous system.

4.4 Optimisation of Teaching Methods and Forms to Study Ecological Chemistry

The article attempts to modify future specialists' ecological training in chemical specialities, integrating sustainable development ideas. Teaching technologies have been improved in several areas to prepare future professionals to work in a sustainable production environment.

To ensure the sustainable development of the student's personality, they tried to promote a conscious attitude to their cognitive activity and create conditions for the most practical knowledge acquisition. Determining the profiles of groups allowed the authors to use the technology of integration of methods, forms and means of teaching, including ICTs, taking into account the peculiarities of the formed educational preferences of students. The use of quantitative criteria for assessing the feasibility of using e-resources on this technology can prevent the emergence of "conflict of styles" of teaching and learning.

The content of educational components was filled with factual material that reflects the current state of environmental ecology. The primary purpose of this was to form students' understanding of the connection between changes occurring in nature due to human-made impact and elements of their future professional activity. It was also important to better align the developed teaching material with the requirements, which dictate the presence in groups of the vast majority of active and sensitive students.

To ensure the organisation of training using ICT, dedicated educational and methodological support was developed. It includes instructions for the self-facilitated execution of computer simulations and sets of multimedia presentations. The developed methodical recommendations for teachers reveal a technique of using the described e-resources in the real educational process.

5 THE PROSPECTS FOR FUTURE RESEARCH

Preliminary diagnosis of students styles in the group allows the teacher to create conditions for enriching students' stylistic behaviour, which will increase the productivity of their intellectual actions.

The use of the educational resources created in this work will help prevent the "conflict of learning styles" of teachers and students.

The paper's findings can be used in higher education institutions' educational process to teach the pedagogical cycle disciplines. For example, "Methods of teaching chemistry in a specialised school and vocational education institutions", as well as professional disciplines "Organic chemistry", "Computer statistical processing results" and others.

Continuing experiments to establish links between students' academic performance and the development of their cognitive styles is a promising area of research. Summarising their results will help to formulate principles for the organisation of efficient training of future chemical specialists.

6 CONCLUSIONS

1. The paper proposes changes in teaching methods and the discipline's content in ecological chemistry teaching. The change in teaching methods and content is focused on optimising e-resources according to students' educational preferences. Individuals' educational preferences were studied for 1-5 year students majoring in chemistry and informatics at KSPU and 1-5 year students majoring in industrial pharmacy at KNUTD.
2. The Index of Learning Style instrument by R. Felder – B. Soloman was used. Most future chemists learn visually, sensitively, actively and sequentially. The styles of undergraduate students majoring in industrial pharmacy are qualitatively similar and show even more pronounced preferences in 3 dimensions. In the glo-seq dimension, pharmacists have a clear advantage in the sequential style, while chemists' styles are relatively balanced.
3. Learning preferences are relatively stable during undergraduate study and vary very little depending on gender or age. Detailed comparisons of undergraduate and graduate students among the future pharmacists show an increase in the number of masters with ref and vrb preferences. So, student profiles in these dimensions become more balanced in passing from undergraduate to graduate studies.
4. Based on individual students' learning preferences, the group profiles are calculated using the previously developed methodology. It considers the rating of e-resources by the average score of student preferences and the difference between the ratings of experts and scores of students with different learning styles.
5. Developed didactic materials, which correspond to the group's educational preferences, were used to teach the topic "Ecological chemistry of the lithosphere".
6. The topic "environmental pollution of plants" contains a large number of concrete examples. The possible introduction of this topic into the syllabus of ecological chemistry aims to improve the correspondence between the content of the discipline and students' educational preferences with a sensitive learning style.
7. In the study, we started introducing students to different work forms that involve different cognitive functions and contribute to their balance. In turn, the latter allows a person to be flexible in the unrestrained development of technological progress, be open to different ways of receiving information and perceiving it without resistance and tension.

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Experience of using ICT Tools for Monitoring the Psychological Component of the Quality of Teacher's Activity of the Higher Education Institutions

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Keywords: Quality of Education, Monitoring of the Quality of Education, Psychological Component of the the Quality of Education, ICT Tools, Psychodiagnostic.

Abstract: The focus of the current research is on the quality of education as a multifaceted category, and the monitoring of the quality of education – as a purposeful and specially organized system of studying, assessment, analysis of data on the state of education of students. Emphasis is on the psychological component of monitoring the quality of education, which involves creating a positive socio-psychological atmosphere for participants in the educational process, both students and teachers. Creating a comfortable atmosphere allows teachers to perform their work effectively, and higher education institutions – implement the main task of ensuring the quality of teaching staff. The article highlighted the experience of monitoring the psychological component of the quality of higher education using various ICT tools – Google services, specially created websites for professional psychological diagnostics, author's programs of psychological testing ("Comprehensive diagnosis of psychosocial development of the teacher's personality using a computer program "Personnel – Ψ""), etc. This study aims to study current conditions, namely the development of digital technologies. The need to use electronic resources (Google services) has increased, which allows you to create text documents, presentations, spreadsheets, forms, drawings, programs and other documents. In order to provide the monitoring of the quality of the psychological component of higher education teachers' activity, Google Forms was elaborated to obtain information about the psychological state and satisfaction with the quality of educational services by the participants of the educational process, their relationship, the socio-psychological climate in higher education and others, amongst to respond to social and educational change on time.

1 INTRODUCTION

In the current conditions of the information society, ICT make changes in all spheres of human life. Relationships between people, organizations, and each other acquire a new format under the influence of various factors: media technology, social media, Internet, COVID-19 pandemic and more (Velykodna, 2021; Velykodna and Frankova, 2021). Information technology enables more intensive communication, and information may be transmitted to one person or a large community.

ICTs are especially important for education. After all, just educational institutions shape society, helping to increase the pace of its economic, sociocultural, political, psychological development, professional development and education of an intellectual elite capable of perceiving, using and producing new information (Büyükbaykal, 2015). Today's challenges require not only new knowledge, information but also strategic reform of higher education in

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Ukraine, due to "the emergence and rapid development of information technology, commercialization, increasing global competition, the effects of the coronavirus pandemic, etc" (Saukh, 2020).

One of the leaders of the information society theory, Masuda (Masuda, 1990), argued that: in the information society there will be no official restrictions on educational institutions; information networks will replace existing education systems; this will reduce the gap between developed and underdeveloped regions; the main form of training will be self-study, and the teacher will act as a consultant on various web platforms; the importance of adult education is growing; replacement of mass education with an education system that meets individual skills and preferences of the individual (Masuda, 1990, p. 289).

Special attention, as noted in the EFA Global Monitoring Report 2005 "Education for All – The Quality Imperative" is paid to the conceptualization of the quality of education (UNESCO and EFA Global Monitoring Report Team, 2004, p. 36), the importance of control and compliance with European standards of educational quality in the information society. It will allow individuals not only to receive a quality education but also to be more independent, plan and control their professional development, and continuously self-progress (Hope and Hope, 1997, p. 11). At the same time, continuity of education is an important element of it, a condition that will promote self-development, self-education, self-improvement and self-realization of the individual throughout life. In particular, the World Declaration on Higher Education for the 21st Century states that teachers in higher education "should not only act as a source of knowledge but also give priority to instilling in students the ability to learn, the ability to take the initiative" (Asatiani, 2018).

The quality of education as a key factor in the country's sustainable development plays an important role in creating an European educational space. The high-quality education itself is an important tool for the creating of the key competences that are significant for the present, the development both of the individual and society, the state as a whole, by ensuring the social and economic growth of the country.

The education right of each individual was regulated by Universal Declaration of Human Rights, and the adoption of the Incheon Declaration "Education-2030: Ensuring of Inclusive and Equitable Quality Education and Lifelong Learning for All" has been set out the fundamental principles for global education development by 2030 (UNESCO, 2015).

The COVID-19 pandemic has made adjustments to the activities of educational institutions and accelerated the digitalization of educational systems (Polhun et al., 2021). However, the increased use of digital media has significant limitations. According to the Rome Ministerial Communique, "higher education should take the lead in studying and advising on overcoming and overcoming these constraints, ensuring cooperation and closer dialogue between countries, higher education institutions and systems and with the wider higher education community". Higher education institutions have the main "potential to stimulate significant change – improving the knowledge, skills and competencies of students and society to promote sustainable development, environmental protection and other critical tasks. Building an inclusive, innovative unified open education program will ensure equal access for all to quality education; use of innovative teaching, learning and assessment methods, information tools that will promote international cooperation and reforms; exchange of knowledge and mobility of both students and teachers" (EHEA, 2020).

The quality of education is considered to be the heart of education for all (Madani, 2019), positively influencing on the changes in student learning (affective, cognitive, and psychomotor domains) and personal and professional potential (Welzant et al., 2015).

The introduction of ICT in the educational process provides the quality implementation of teachers, training of students, the formation of their professional competence in the information society, the development of intellectual and creative potential, which depends on the level of personal qualities such as motivation, success, self-esteem, subjective locus of control (Balakhtar, 2018). Therefore, updating the experience of using ICT tools to monitor the psychological component of the quality of higher education teacher is extremely important today.

The introduction of ICT in the educational process of higher education institutions reflects one of the most important trends in the global information society. ICTs can be both an object of study and a learning tools (Semerikov et al., 2021). In other words, there are two ways of their formation: the study of computer science (Ponomareva, 2021) and the use of ICT in professional activities (Kramarenko et al., 2021). According to Vakulenko (Vakulenko, 2003), ICT of education are "a set of software, hardware, computer and communication tools, as well as methods and innovative methods of their application to ensure high efficiency and informatisation of the educational process".

ICT are appropriate and effective for assessing learning outcomes, create new opportunities for individualization and differentiation of the educational process, allows you to easily and quickly adapt to the new requirements of the monitoring of the quality of education, ensuring the creation of an optimal environment for educational services, understanding of human behaviour in the social environment, life cycle development and interaction between biological, psychological, socio-structural, economic, political and cultural factors of the educational process (Balakhtar, 2018).

The monitoring is an integral part of the management of the quality of education; a means of information diagnosing in the process of carrying the managerial decisions, analysing the educational activities, predicting the changes in the educational process etc. The alteration of the living conditions places the new demands on the quality of education, which requires the study and evaluation of education indicators, the monitoring of the quality of education as a major driver of personal growth and development, as well as the consideration of psychological factors of higher education quality that contribute to the development of the creative and safe environment in higher education institutions (Bondarchuk, 2017).

Modern ICT is characterized by the presence of a globally voluntarily integrated system of computer networks (web) and its services (e-mail, www, etc.), which allow you to quickly obtain the necessary information (testing using Google Forms, online surveys, forums, etc.). Digital data is easy to account for, statistical analysis and more. However, nowadays, despite the relevance of monitoring studies in the education system, there are no uniform requirements for their organization and application. There are also no general criteria for assessing the quality of education and the ability to take into account the direct impact of monitoring as a tool, a method of influencing the quality of education. This effect can be both direct and indirect.

Thus, the direct influence of the technology of implementation of monitoring methods and its subject area, and indirect allows taking into account the results of monitoring in management decisions, correction of the activities of participants in the educational process (Bazhenov et al., 2015, p. 104).

It is expedient to conduct monitoring research:

- to ensure the quality of educational activities and the quality of education;
- to develop strategies, policies and procedures for ensuring the quality of education;
- to study the needs of participants in the educational process;
- to manage educational activities in higher education institutions, etc.

Thus, the monitoring works as a tool for correcting the educational process, the activities of all participants in the educational process (both teachers and students), ensuring the quality of education and the conditions of its implementation.

The quality of educational process and the effectiveness of the knowledge provided are impossible without diagnostics and monitoring, among which the diagnostic forms are questioning and testing. From this perspective, Google services attracts our attention as an innovative tool of cloud technology, which let us control, collect, summarize and analyse the information through questionnaires (surveys) using simple online forms (Google Forms), view the spreadsheets, and visualize the survey results in graphs and charts for further analysis.

Google Forms is utterly convenient tool, the online-service for forming the feedback forms, tests and surveys in order to organize the remote interaction of participants and experts in the framework of the assessment of the quality of higher education. These are the complex sets of questionnaires or computer programs that provide personality testing, determining its psychosocial suitability for work, study. Complexes may be used to determine the opportunities for professional and personal growth, status and psychological compatibility of team members, learning, selection and distribution of specialists in institutions and organizations, etc.

2 LITERATURE REVIEW

Monitoring the quality of teachers of higher education institutions contains an information system that is constantly updated and replenished based on continuous monitoring of the state and dynamics of the main components of educational quality on a set of defined criteria to develop management decisions to correct undesirable imbalances based on analysis of collected information and forecasting the further development of the studied processes (Serhiyenko and Sorokina, 2013).

Monitoring makes it possible to collect and analyze information to study and evaluate the quality of education and educational activities and make decisions on the development of the educational process based on the analysis of identified typical features and trends. It is the methods of online assessment (online tests) that have significant advantages (Wen and Tsai, 2006) because they make it possible to measure and evaluate student performance, acquaintance, guide the educational process, accelerate the reporting process, and so on. Online tests help ensure privacy and are more economical.

In general, monitoring studies of educational problems using online applications for testing originated in the 1970s in the United States (Gül et al., 2015). The results of the research showed significant advantages, namely: impartiality of assessment, speed of controlled validity of the test, accuracy, scope, and the possibility of international scope.

Mills et al. (Mills et al., 2005), Russell et al. (Russell et al., 2003) have confirmed correlations between online forms and offline forms of testing to measure intelligence and personality abilities. There were no significant differences between the test results. We are impressed by the opinion of Pellegrino et al. (Pellegrino et al., 1987) concerning the use of stable and mobile objects in research through computer technologies (drawing, recording the reaction time of the answer to test tasks, etc.

Reliability, the validity of online tools (reliable, valid data gathering instrument) while studying the attitude of teachers to educational activities, to methods of online assessment on the Internet substantiated by Gül et al. (Gül et al., 2015).

The quality of education is a problem that worries the whole world community. The qualities of education as a component of the "Education for All" program is a broad concept and without single interpretation defining its essence, content and components by now, moreover, but as Haddad and Demsky (Haddad and Demsky, 1995) claim, it depends on the policy of the state. Quality education includes: students, educational environment, content, process and results.

The Law of Ukraine "On Higher Education" regulates the quality of higher education as "the level of knowledge, skills, abilities and other competencies acquired by a person, which reflects its competence following higher education standards" meets the standards of higher education, ensures the acquisition of quality higher education and promotes the creation of new knowledge" (Verkhovna Rada of Ukraine, 2015).

"National Education Glossary: Higher Education" defines the quality of (in) higher education as "a characteristic of higher education that reflects the compliance of learning outcomes, educational processes and institutional conditions with the current goals of personal development and society" (Zakharchenko et al., 2014).

The concept "quality" is constantly influenced by economy, politics, culture, so it should be flexible, capable of changing during the evolution of education and progress (Glasser, 1990). For instance, changeability, fairness, efficiency and quality are often used as synonyms (Glasser, 1990).

The quality of education as a multifaceted category by its essence covers various aspects (philosophical, pedagogical, psychological, social, economic, etc.). Thus, the quality is understood as the normative level to which the product of enlightenment corresponds (Shamova et al., 2002); the level of achievement of certain goals and objectives of education, set of indicators characterizing various aspects of the educational process (content of education, forms and methods of teaching, etc.) (Shishov and Kalney, 2000) and others. The quality of education is about the value of education (with reference to its contribution to the learning process and its outcome) (Babalola, 2004).

Control and monitoring of the quality of education, continuous monitoring of the educational process in order to identify its compliance with the desired result and determining, where necessary, corrective and developmental measures, are the important tasks of monitoring aimed at the systematic collection, processing, storage and dissemination of information on the state of education, forecasting with reason of objective dynamics data and the main tendencies of its development and science-based recommendations making to take the managerial decisions according to the improving the efficiency of the education industry functioning; the current adjustment of higher education institution's activity (ENQA, 2015) etc.

The monitoring of the quality of the teachers' educational activities in higher education institutions in accordance with the public requirements and stakeholders' needs provides a purposeful and specially organized system of continuous (regular and planned) observation (study), measurement, evaluation, analysis of data on various aspects of teachers' professional activity, consequently, the forecasting, the development of science-based recommendations for timely management decisions due to the improving the quality of the educational process and results.

2.1 The Monitoring Psychological Component of the Quality of Higher Education

Monitoring the quality of higher education determines the state and effectiveness of the educational process in higher education institutions, its compliance with the requests of society and the individual; alongside, provides an opportunity to anticipate further steps to improve its quality.

According to the "Standards and Recommendations for Quality Assurance in the European Higher Education Area" (Balakhtar, 2019), higher education institutions are in charge of the competence of teachers and providing them with a favourable environment. Creating a comfortable atmosphere allows teachers to perform their work effectively and higher education institutions – implement the main task of ensuring the quality of teaching staff.

Monitoring the procedures for ensuring the quality of education in higher education should, first of all, give a clear answer to the question of creating a positive socio-psychological atmosphere for participants in the educational process, both students and teachers. After all, the quality of the educational process depends on the teaching staff. Therefore, to ensure the quality of higher education, the leadership of the Free Economic Zone should create an environment in which the teacher: values his/her professional skills, seeks to improve, develop, generate original ideas, and implement them in the educational process. Moreover, the teacher wants students to intensify their activities; to develop tolerance; to form critical thinking, their worldviews and so on (Vasyliuk et al., 2019). These and many other issues need special attention of the Free Economic Zone.

Monitoring of quality assurance procedures in higher education institutions should give a clear answer to the question of how clear, transparent and fair the enrollment procedures are; opportunities for the professional development of teachers; ways to stimulate scientific activity, conducting research; motivation to implement innovations, creative teaching methods and the use of new technologies.

Monitoring is one of the most crucial tools which changes the information space, improves efficiency, objectivity and accessibility of information, allows identifying problems that have arisen in the process of achieving educational goals; identifying trends in education to develop appropriate educational policies, and identify psychological atmosphere in the educational institution. Thus, monitoring serves as a mechanism for ensuring quality education.

The higher education quality as transformative process leads to a focus on psychological factors of quality of higher education which contribute to the development of a creative and safe educational environment (Bondarchuk, 2017). *The psychological component of the monitoring of the quality of education* involves the providing the information about the psychological status and satisfaction with the quality of educational services of the participants of the educational process, their relationship, the socio-psychological climate in higher education institutions, etc.

The criteria of this component are: satisfaction of the requests and needs of the listeners, and indicators:

1) the level of satisfaction of the requests and needs of the listeners;
2) the relevance of the training content to the listeners' professional needs and the stakeholders' requests of as a whole;
3) the listeners' psychological status and level of satisfaction with the quality of educational services;
4) the nature of the relationship between the participants of the educational process and the level of satisfaction with them;
5) the socio-psychological climate in higher education institution as an indicator of the level of development of organizational culture (Babalola, 2004, p. 6).

Therefore, it should be indicated, as the educational practice shows, the regular study and the assessment of the data is directly or indirectly carried out mainly by the first three indicators.

Hereat, the analysis of data on the relevance of the quality of education to the requests not only of listeners, but also of stakeholders, as a whole, indicates the expediency of intensifying the processes of self-education, self-knowledge and self-development of education workers, improving their qualification. In particular, this is evidenced by the results of a large-scale study made by us during 2014–2019 (about 1000 respondents from all regions of Ukraine who passed the advanced training at the Central Institute of Postgraduate Education of University of Educational Management) the attitude of the education institutions' employees to their psychological competence, by which the ambivalent character was revealed (ENQA, 2015). In particular, assessing positively the results of the acquisition of psychological competence in higher education institutions, the respondents-educators mainly note its need to influence other participants of the educational process. Simply a small part of the listeners (less than 10%) remarks the expediency of using the acquired knowledge for introspection, reflection of the process of their professional and personal development.

In regards to the indicators "the nature of the relationship between the participants of the educational process and the level of satisfaction with them"; as well as the "the socio-psychological climate as an indicator of the level of development of organizational culture", they were, despite all actuality, practically not monitored. Thus, the psychological component of the monitoring of the quality of education is not fully implemented and requires the special study, the procedure of which is greatly facilitated by the use of Google services.

2.2 ICT Tools in the Educational Activity

It is well known that ICT are currently considered to be a wide range of digital technologies used to create, transmit, disseminate information and provide services (Internet, e-mail, software, psychodiagnostic etc.). Google services include many concepts (infrastructure, platforms, software, data, etc.).

In the study, we will understand ICT as a set of various technological tools and resources used to ensure communication, ensuring the quality of education and the quality of educational activities, creation, dissemination, storage and management of information by determining the most complete and optimal content of personal competence of participants, their professional knowledge, skills, abilities and qualities (Balakhtar, 2018). In particular, you can use traditional – Google services, and supplementary specially designed websites for professional psychological diagnosis (Kremen and Bykov, 2013), author's psychological testing programs, for example, "Comprehensive diagnosis of psycho-social development of the pedagogical worker with the computer program "Personal – Ψ" (V. Kyrichuk) and others.

According to Burlachuk (Burlachuk, 2008), computer psychodiagnostic is a research field that involves the usage of computer technology to examine and analyze the results, likewise the development and application of computer tests. This research area aimed at developing tools and methods of computer psychological diagnostics, accompanied by the boost of fundamentally new types of research and working methods with psychological information (Maksymenko and Kokun, 2019).

Maksymenko and Kokun (Maksymenko and Kokun, 2019) substantiated the theoretical, methodological and practical principles of designing diagnostic websites to ensure the practical implementation of remote (online) professional psychological diagnostics. According to scientists, compliance with the policies proposed by them guarantees psychological diagnosis websites: attracting visitors, maintaining the required level of their confidence and interest; provides anonymity, clarity, convenience and ease of use; has a high information value, richness of content and scientific nature; allows to differentiate respondents and help to receive feedback from them.

The main function of Google services is to meet the users' needs required the remote processing and storage of data (Kremen and Bykov, 2013). Google services is a full-fledged educational tool which enables most effectively to create the own online space and form a personal educational environment for teachers and students of higher education institutions. Google services is a flexible cost-effective model that can be easily and quickly adapted to new software requirements, supporting the standardization of such software and various applications, simplified maintenance through centralized updates. Moreover, they are supported by various devices (tablets, laptops, desktops, etc.) of teachers and students; can be used both in educational institutions and abroad; enable to save time and increase security through the remote control and maintenance, etc. (Spirin and Vakaliuk, 2019). Using Google services enables to develop the digital competency (the ability to consciously and critically use the digital society technologies), as well as the information and communication competence as a person's ability to use information and communication technology in practice to meet individual needs and solve the socially significant, in particular, professional tasks in a subject area (Bakum and Morozova, 2015; Vlasenko et al., 2019; Moiseienko et al., 2020; Bondarchuk et al., 2020).

There are many types of Google services, but in the context of the problem under study we are interested in the service of the Google Drive cloud storage that can help organize the monitoring of the quality of education etc. In order to work with it, the Gmail account should be created. The browser-based application is available for free to create any number of Google Forms (web pages) that host a form or a questionnaire. Google Forms opens up an extremely wide field of opportunity and creates an opportunity to achieve the stated goal in a short time and collect answers to your questions.

2.3 The Monitoring Procedure of the Quality of the Psychological Component of the Educational Process

Therewith, the improvement of the internal system of the ensuring with the monitoring of the quality of education in higher education institutions, we have compiled a series of express methods (based on Google Form) on the indicators "the nature of the relationship between the participants of the educational process and the level of satisfaction with them", "the socio-psychological climate in higher education institutions as an indicator of the level of development of organizational culture", etc. scientifically-based recommendations for further improvement of the quality of the educational process in the educational institution by the psychological component.

Google Forms permits: to make the questionnaire available to respondents as soon as it is created, upon it can be edited, meanwhile the questions can be opened and analysed; to embed it on a site page, distribute it through mobile networks, where it can be filled by potential respondents; the service automatically to generate a spreadsheet to collect and process the responses to the author of the form, and to display the results of the survey as a spreadsheet (or filtered list) which has all the features and capabilities of a regular Google chart; the service to make it possible to view the answers of all the respondents and separately each of them individually without a spreadsheet, but with the appropriate statistics in the diagrams and graphs data given in qualitative and percentage values formats; to summarize the answers in graphical and numerical format.

We have created the Google Forms (ENQA, 2015), namely “The Quality of the Educational Process: the Psychological Component” containing four techniques. The first method due to the assessment the psychological atmosphere in the unit (team) proposes to choose the opposite by contents pairs of words (by A. Fiedler), which allows describing the nature of interpersonal relationships in the unit (Fetiskin et al., 2002).

The respondent chooses the correct answer for him/her and puts a mark in each pair (1 to 7), thereby choosing closer to the right or left word, which indicates a more pronounced sign of interpersonal relationships in the unit, such as “agreement” or “disagreement”, “satisfaction”, “dissatisfaction”, etc. (figure 1).

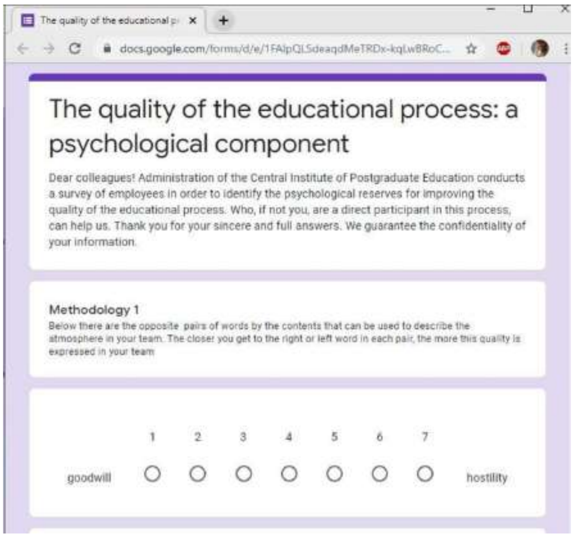

Figure 1: The interface of Google forms for learning the quality of the educational process.

The screenshot highlights the title of the study “The Quality of the Educational Process: the Psychological Component”, as well as the Method 1 instruction for the respondents to determine the psychological atmosphere in the team.

During the implementation of the second methodology for the diagnosis of psychological atmosphere in a small production group (authors – V. Shpalynskyi, E. Shelest) (Bondarchuk, 2018), in the adaptation of O. Bondarchuk), on a 5-point scale, the respondents rate the degree of their favourable climate for the team (goodwill, trusting relationships, joy for success of colleagues, relations with management, adherence to rules in the team, etc.) (figure 2).

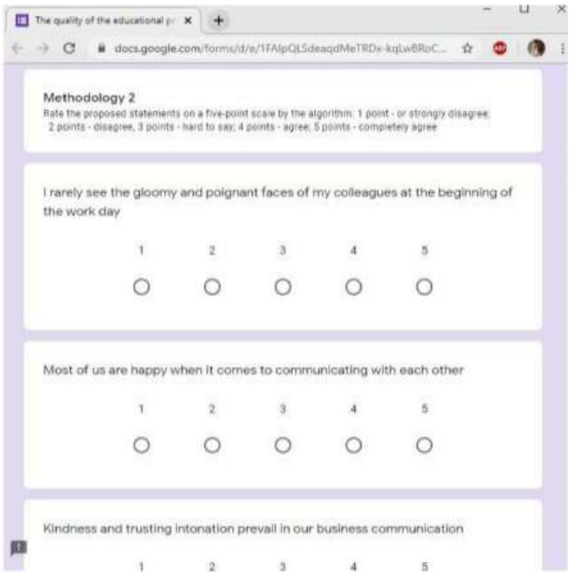

Figure 2: The interface of Google forms for learning the psychological climate (Method 2).

Referring to figure 2 the Method 2 “Rate the proposed statements on the 5-point scale by the algorithm” is shown on the previous screenshot:

1 point – strongly disagree;
2 points – disagree;
3 points – hard to say;
4 points – agree;
5 points – completely agree.

Based on the answers of the respondents, the Google Forms gives an opportunity to determine the level of favourable (high, above average, average, below average and unfavourable) psychological climate in the team.

Likewise, the Methods about learning the group cohesion (Sisor Index, adapted by O. Bondarchuk) and the psychological security of the educational environment, allowing determining the level of the psychological security in the educational environment (by I. Baeva, modified by O. Bondarchuk (Bondarchuk, 2018)), (The Methods 3 and 4 respectively) were applied.

After filling in the Google Form, the respondent must click the button "Submit" (figure 3).

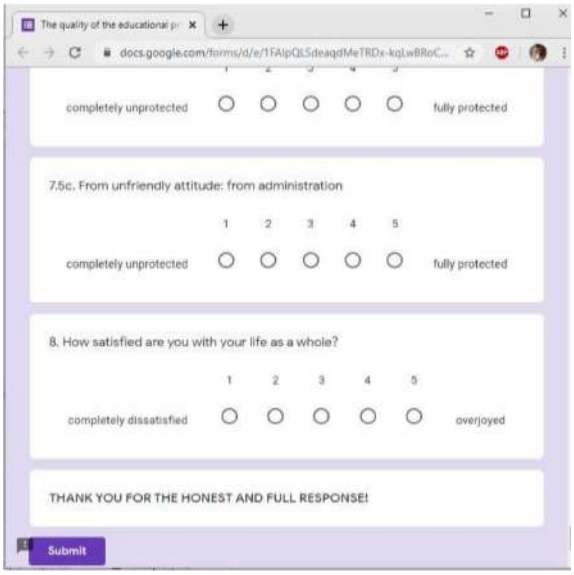

Figure 3: The interface of the "Submit" function.

Referring to figure 3 the screenshot shows the option of choosing the answers for the employee's protection "From the unfriendly attitude of the administration" and "How satisfied are you with your life as a whole?". The "Submit" function is visible at the end.

After receiving the answers, we are able to review them, create a spreadsheet or chart where it is possible to examine the statistics for each question, analyse appropriately, evaluate etc. The results of the answers can be obtained in the form of the linear scale figure 4 or diagrams figure 5.

The example of the analysis of the answers in the form of the linear scale to the question "Would you go to another unit if this opportunity happened (without changing other conditions)?" and "What are the relationships between the members of your unit?" is given in figure 4.

The results of the study provide the following answers to the question – "yes, I would strongly like to move", "I do not know, it is hard to say", "would rather move than stay", "see no difference", "most likely would stay in to my unit", "would strongly like to stay in my unit".

The analysis of the results enables to make a deep analysis of the psychological conditions, as well as facilitate the development of recommendations, programs for improving the social and psychological climate in the educational institution.

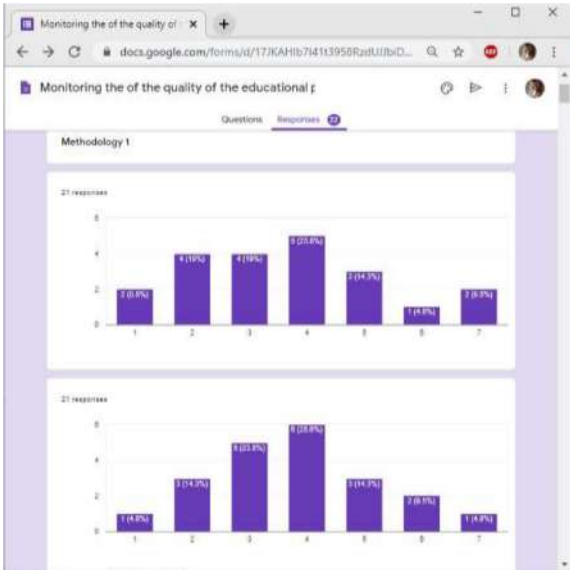

Figure 4: The statistical analysis of the answers to the questions in the form of the linear scale.

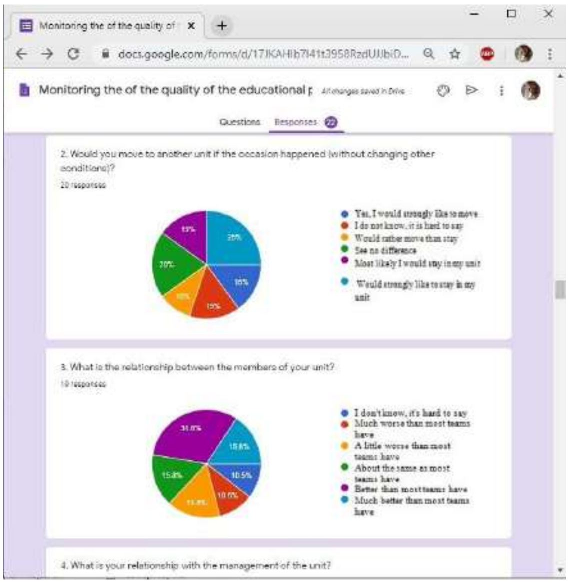

Figure 5: The statistical analysis of the answers to the questions in the form of diagrams.

Thus, in particular, the analysis of the results of the pilot survey of the Yuriy Fedkovych Chernivtsi National University and University of Educational Management teachers, the case of which is given in figure 5, allows to conclude about the significant problems of the psychological assurance of the quality of education, nevertheless, as it is seen from the figure, just 47.8% of teachers consider the relations in the team as favourable. 25% of respondents would change the jobs. It is quite problematic to provide a student-centred approach to the organization of the educational process in such situation

Accordingly, it is urgent to develop the special psychological and managerial measures to minimize the revealed negative tendencies in the activity and interaction of higher education institutions teachers.

To ensure the psychological component of the quality of higher education and its diagnosis, the teacher of the Department of Management Psychology of University of Educational Management V. Kyrichuk developed a computer program "Comprehensive diagnosis of psychosocial development of the teacher "Personnel – Ψ".

The comprehensive program allows for personality testing determining psychosocial suitability for work in various fields of science and production, opportunities for professional and personal growth, status and psychological compatibility of team members and more. It is practicable to use the complex also for the study, selection and distribution of specialists in institutions and organizations.

The program allows you to direct testing in different directions (figure 6):

1. "Data" – This section allows you to enter personal data, edit data on existing staff, save and download data from a file.
2. "Polls" – The section includes questionnaires and allows you to print them, i.e.:
   - personality type;
   - features of interpersonal relationships;
   - features of professional-pedagogical activity;
   - socio-psychological attitudes;
   - personality orientation;
   - motives and motivation of activity;
   - leadership and leadership styles;
   - teamwork.
3. "Forms" – The section includes answer sheets and allows you to print them.
4. "Testing" – The section allows you to enter the results of blank testing.
5. "Dialogue" – This section allows you to test with questions on the monitor screen.
6. "Characteristics" – The section includes test results, allows you to view and print text and graphic characteristics of the tested persons
7. "Statistics" – The section includes statistical information for the team and also allows you to select staff for various social and psychological criteria for the study.
8. "Conclusions" – The section includes problems and potentials of one or a group of respondents, as well as to design an algorithm for solving problems through potentials.
9. "Options" – This section allows you to configure the technical parameters of the program.
10. "Help" – The section includes help with the program.

Figure 7 shows an example of a test interface with the input of results into the database of the program for processing. Besides, it is possible to view and print statistical data according to the socio-psychological guidelines of the team, which is sorted by social indicators or selected in the section "Selection of persons for statistics".

The program includes a group of techniques (questionnaires) that allow you to obtain diagnostic information that lets you quantitatively and qualitatively compare the individual (group) with other individuals (groups) according to some psychological and social parameters.

The program allows testing in the form of a simple dialogue with the user: to study the motives and motivations of the individual, professional traits, aspirations and preferences, leisure activities, opportunities to work in a team, etc (figure 8).

It is acceptable to see the graph on the vertical axis shows the number of people who correspond to one of the levels of motivation, and on the horizontal axis four types of motivation. The table shows the level of motivation for each person separately.

The program generates a personality characteristic based on the results of all passed tests. The characteristic or type of personality contains a description of the vital qualities as a bunch of the most developed abilities; analysis the possibilities of realization of qualities in practice. The program also determines the features of the teacher's thinking (theoretical or practical); communication; peculiarities of value, motivational, cognitive spheres; ability to work in a team; leadership qualities, etc (figure 9).

The computer program "Personnel – Ψ" enables to determine the psychological portrait of the team on the teachers' individual characteristics in the team of higher education (figure 10).

The psychological portrait takes into account the following indicators:

- personality type (12 types),
- orientation (orientation can be determined as for individual and for the team as a whole)
- interpersonal relationships (authoritarianism, moderation, dependence, aggression, ability to cooperate, altruism, etc.),
- priority values (process, result, altruism, selfishness, work, freedom, power, money),

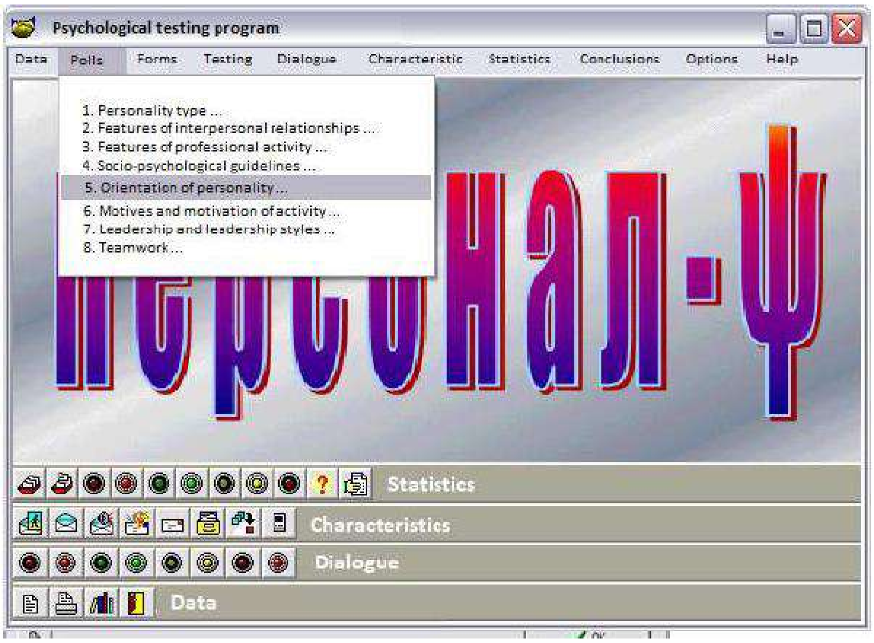

Figure 6: The interface of complex diagnostics of psycho-social development of individual educational worker using a computer program "Personnel - Ψ".

- teacher as a professional (value priorities, psycho-emotional style, self-esteem, teaching style),
- motivation (aspiration, success, willingness to take risks, avoidance of failures, etc.),
- management style (authoritarian, passive, democratic),
- leadership (leadership, management styles and self-management in the team),
- driving style (levels of truthfulness for each individual and in the team as a whole)

The program saves data about respondents, creating a database. In the section "Statistics" you can search and elect staff according to socio-psychological criteria.

According to the selected parameters, the program formed a portrait of the individual or group of respondents as a whole, which makes it possible to predict and project the rise of business and interpersonal relationships of the individual in the team (figure 11).

Figure 11 shows the graph on the vertical axis shows the number of people who correspond to a certain type of orientation, and on the horizontal axis six types of orientations. The percentage of types of orientations in the team is also shown. The table shows the focus on each person separately.

The computer program "Personnel – Ψ" according to the test results offers to review the problems and potential capabilities of the person and the whole team (figure 12, figure 13).

Figure 12 shows that the program analyses the existing problems in the teaching staff, alongside determines the number of people who have another case. The program presents the following: insecurity in their abilities; tendency to self-oppression, obedience, submission to all, passivity; lack of conformism, criticism, ability to find common ground; hyper-responsibility, sacrifice in the interests of others to the detriment of oneself; indifference to the problems of others; insufficient interest in the work process; lack of confidence, perseverance, desire to succeed; there is no independence in decision-making; the need for help and support; excessive desire to work; unstable self-esteem; excessive self-demand; feelings of dissatisfaction with work, anxiety, fear, insecurity; lack of manifestation to help others; too much self-sacrifice for the benefit of others and to the detriment of oneself; deep experience of failure, deviation from a moderate, realistic lifestyle; insensitivity when communicating with people; initiator of the conflict, organizer of opposition to any leader, etc.

In addition, the program allows you to determine the potential of the teacher and the entire teaching staff of the educational institution (figure 13): the ability to organize the work of the group, the tendency to leadership; loyalty to others; self-confidence, independence to have one's own opinion; conformism in adapting adequately to the situation; desire for cooperation, tendency to compromise; attention to the concerns of others, emotionality, desire to support others;

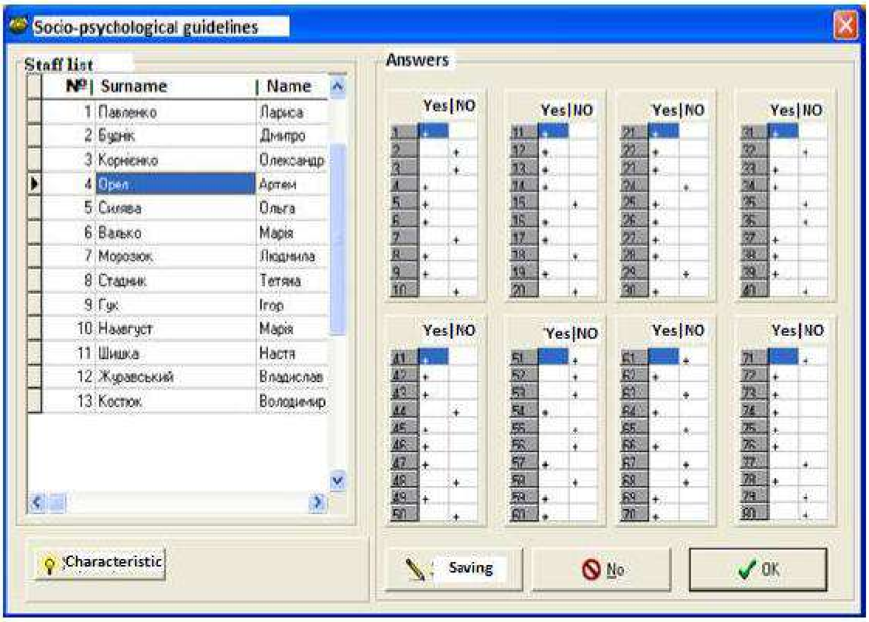

Figure 7: The testing interface with entering the results into the database of the program to be processed.

Figure 8: The testing interface in the form of a simple dialogue with the user.

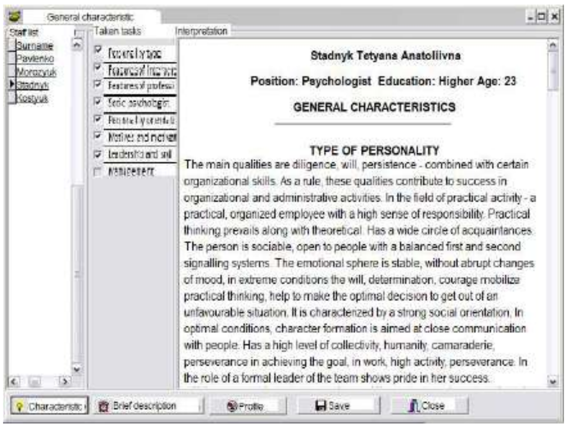

Figure 9: The interface of generating the program characteristics based on the results of all tests passed.

the process of work captures on a par with the end result; confidence, persistence in achieving the result; the presence of positive selfishness for the benefit of oneself and others; persistent desire to work; the ability to independently choose a decision or action; purposefulness, the presence of strong-willed qualities; a sense of the reality of receiving and spending money; a positive psycho-emotional state increases work efficiency; property of positive self-education; adequate assessment of success in activities and status in the team; confidence in situations of achieving real goals; realism in choosing goals in order to achieve success; high risk appetite; close acceptance of students' interests and problems; high degree of acceptance of oneself and others, good psycho-emotional state; lack of supremacy, authoritarian tendencies, etc.

After testing, it is possible to view and print the results, also the computer program "Personnel – Ψ" offers socio-psychological guidelines for both the individual and the team of teachers, in general (figure 14).

Thus, monitoring the quality of the psychological component of educational activities in higher education institutions using the computer program "Personnel – Ψ" showed the feasibility and effectiveness of its use.

The program allows not only to explore the psy-

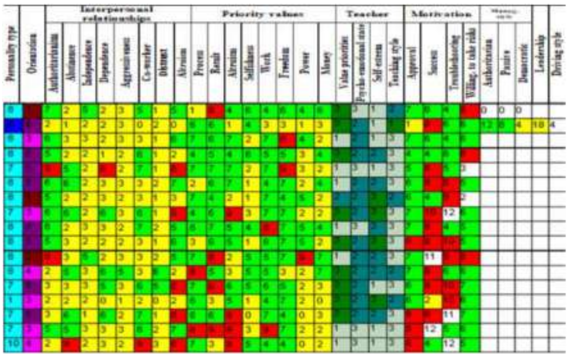

Figure 10: The interface "Psychological portrait of the team" of the computer program "Personnel – Ψ".

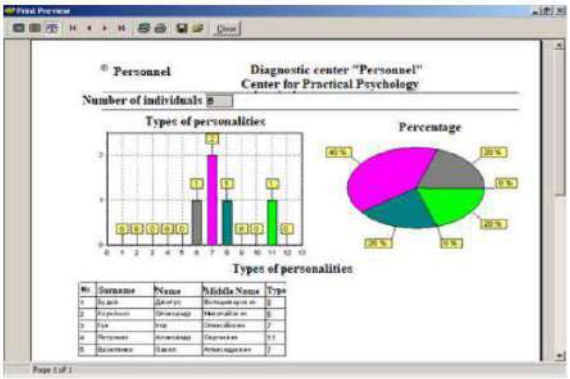

Figure 11: The interface of the "Statistics" section of the computer program "Personnel – Ψ".

chosocial development of teachers but also identify problems, offer socio-psychological guidelines, taking into account the potential of the individual (of the team), improve the quality of education and educational activities in higher education.

2.4 Appraisal of ICT as a Tool for Monitoring the Quality of Education

In nowadays conditions, the importance of lifelong learning is growing, which gives impetus to the development of new models, ICT, which contribute to the emergence of both new approaches to learning and new forms and methods of interaction (Balacheff, 1993).

ICT is not only a tool for learning that allows you to solve real problems of the educational process, using simulation systems to analyze situations (Hampel et al., 1998), but also provides an enabling environment that helps teachers and students create a climate of collaborative knowledge building, thereby changing their traditional roles (Bottino et al., 1999) and forming a new understanding the process of teaching, learning, developing methods to transform these new views into educational practice (Forcheri and Molfino, 2000).

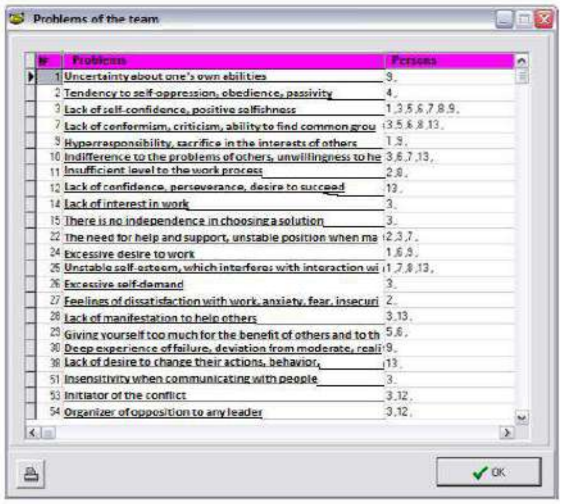

Figure 12: The interface of the section "Statistics": "Problems of the team".

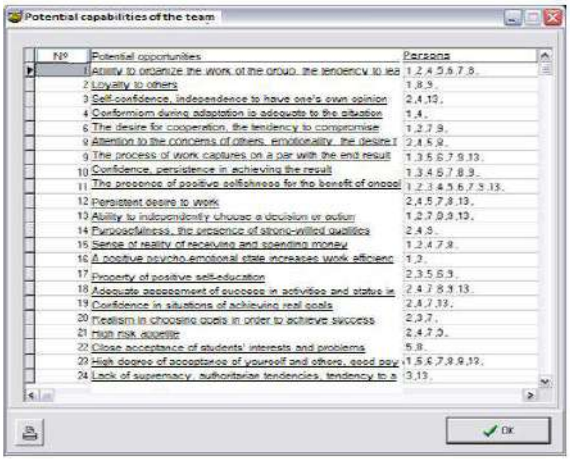

Figure 13: The interface of the section "Statistics": "Potential opportunities".

Among the advantages of using ICT, in particular for monitoring the psychological component of the quality of education in higher education institutions, scientists (Maksymenko and Kokun, 2019; Bykov et al., 2019; Hänsgen and Perrez, 2001) identify:

- increase the efficiency of activities due to (due to) the speed of data processing and the ability to cover a large amount of research (scale) in a short time by simultaneously testing many respondents;
- the ability to focus on solving exclusively professional problems;
- clarity, reliability and validity of research and ex-

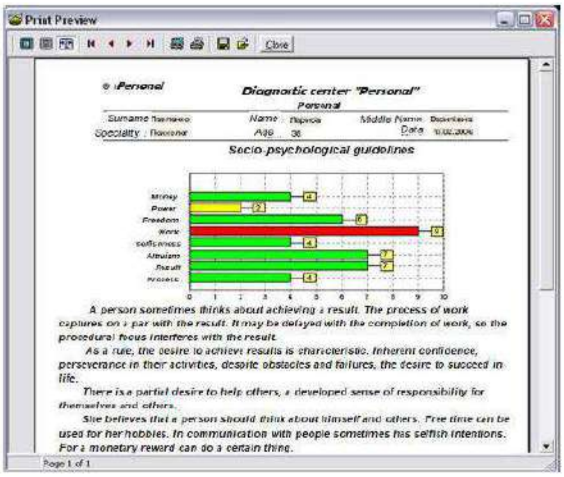

Figure 14: The interface of the program section “Personnel – Ψ” “Socio-psychological guidance”.

clusion of data processing errors that can be made by manual calculation of the original data;

- standardization of diagnostic conditions due to the same instructions for all respondents;
- the possibility of both presentation and re-examination of the survey results separately by each respondent and all together;
- the ability to be more precise and more open to respondents during testing due to the confidentiality and automation of testing;
- opportunity to enrich the experience of teachers with the help of a computer, interpretation of test results;
- the ability to collect statistical data of the respondent (team) and store test results for a long time;
- re-diagnose, analyze and compare data.

Oleg Kokun substantiated the theoretical, methodological and practical principles of development of diagnostic website design for the practical implementation of the computer for professional psychological diagnosis personality (on the Internet). Researcher claim that adherence to the principles defined by them guarantees: attracting visitors and maintaining a certain level of their confidence and interest; ensuring anonymity, clarity, convenience and ease of use; high information value, content and scientific nature of websites; differentiation of respondents and assistance in obtaining feedback. Scientist have developed websites for professional psychological diagnostics, which have been implemented and tested in practice (http://prof-diagnost.org, http://hr-test.org).

The sites have different orientations and contribute to the solution of various research tasks: psychophysiological support of becoming a specialist by the type of professions “person-person”; study of psychophysiological patterns of professional self-realization of the individual; adaptation of the scale of psychodiagnostic methods, occupational stress and the scale of occupational disability, etc.

The monitoring of the quality of education with Google Forms enables swiftly to get the feedback from the participants of the educational process on the quality and outcomes of the educational activity. This is evidenced, in particular, by the validation of the Google Forms created in the pilot study, which confirmed the efficiency in obtaining information, analysing the quality and percentage values in graphical and numerical format, reaching a large number of participants in a short time.

It is noteworthy, that the data from a Google Forms spread sheet is easily imported into other spreadsheets (including SPSS) with aim of in-depth processing of results using factor, cluster or regression procedures and other kinds of statistical analysis.

Based on the evaluation of the monitoring results of the quality of education, a set of corrective and developmental measures is determined in accordance with the conceptual goals and objectives of the functioning and transformation of the educational system presently (Fetiskin et al., 2002).

Consequently, the usage of Google services, the Google Forms notably, contributes to the improvement of the internal system of the ensuring the monitoring of the quality of education, the development of science-based recommendations for the further improvement of the quality of education in higher education institutions with the psychological component, and furthermore, the improvement the competitiveness and attractiveness of educational institutions in regard to the analysis of their resources.

The documents and spreadsheets, created by using Google services, are stored on a Google servers (or can be saved to a file) (Kondratenko et al., 2016), which is one of the key benefits of the program, since the access to the given data may be entered from any computer or mobile phone connected to the Internet.

Furthermore, the obtained resources can be used to adjust the management system in the educational institutions, managing goals, vision, mission, the educational environment (Sranamkam, 2014), as well as to increase motivation and efficiency (Lukina, 2007), to train a person to learn and apply modern international relations.

3 CONCLUSIONS

The authors describe research related to monitoring the psychological component of higher education quality through the introduction of ICT in education – a set of various technological tools and resources used to ensure communication, quality of education and quality of educational activities, creation, dissemination, preservation and management information by determining the most complete and optimal content of the formation of personal competence of participants in the educational process, their professional knowledge, skills, abilities and qualities. These are Google services, specially created websites for professional psychological diagnostics, author's programs of psychological testing (Comprehensive diagnostics of psychosocial development of the pedagogical worker's personality with the help of the computer program "Personnel – Ψ"), etc. ICT capabilities open up a vast range of possibilities, allow you to create sites, programs, text documents, presentations, spreadsheets, forms, drawings and other documents.

The organization of monitoring the quality of the psychological component of education using Google Forms allows not only to determine the nature of relationships between participants in the educational process and their level of satisfaction, and the socio-psychological climate as an indicator of organizational culture but also to make management decisions and forecast the educational environment; promptly intervene and make appropriate adjustments to the learning process; specifically, plan work on the relevant problem in higher education institutions; to create conditions for comparison of own estimation of activity of pedagogical collective with independent estimation.

Thus, there is an urgent need to develop a reliable and effective set of tools for holistic and operational monitoring of the quality of education through Google services, not only for the psychological component but also for all criteria and indicators of higher education, which determines the prospects for further work.

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Analysis and Application of Semantic Networks in Education

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Abstract: The basis of any discipline is a set of didactic units. The task of the educational process management apparatus is to ensure compliance with the requirements for the order of the didactic units and their full implementation within the framework of the formation of the curriculum while minimizing its duration. A significant difficulty is the logical linking of didactic units with each other, since it is impossible to break the logic of presentation of materials of one discipline and there is a relationship between didactic units of different disciplines. The paper compares the topological characteristics of the concept graphs related to various disciplines. We develop the algorithm to implement the subject area model in the form of a semantic knowledge network. 125 concepts are analyzed that provide optimal mastering disciplines and establish the connection between them. A survey of the dynamics of the popularity of the term "network science" from 2004 to 2020 using Google Trends showed a steady trend of user interest. On average, 80 requests are executed (calculated in arbitrary units), with the largest volume of requests being 100.

1 INTRODUCTION

Education is the foundation of sustainable development and the main tool for creating a humane, equal and attentive society to human problems, in which each individual should have his or her human dignity. Obviously, the main reason for the emergence of education for sustainable development is the awareness of the need for changes in the educational paradigm in order to further sustainable development of society, the economy and preservation of the environment. Sustainable development education involves a transition to an economically and socially oriented learning model. This model should be based on broad interdisciplinary knowledge, which is based on an integrated approach to the development of society, and allows making and implementing decisions at the local and global levels. All these steps are aimed at improving the quality of life and do not threaten the ability of future generations to meet their needs.

Many researchers consider the problems of education modernization in the framework of sustainable development. In recent years, the interest in research concerning Education for Sustainable Development (ESD) has grown considerably. In research (Grosseck et al., 2019) using a bibliometric approach, analyzed 1813 papers on the subject, indexed by the Web of Science, between 1992 and 2018. The number of publications, authors, and journals has increased, proving that ESD has gained momentum over the period examined in the study. In study (Grosseck et al., 2019) illustrates two main research directions for the entire time span: integration of education into sustainable development and of sustainable development into education. In study (Holfelder, 2019) is to show that education must be thought of as something other than just training: considering education predominantly as subjectification holds the possibility for open and alternative futures. that education is more than training. The main message – education is more than training. Evaluation case studies in (Eilks, 2015) show that thoroughly combining the ESD framework with science teaching that follows a socio-scientific

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issues-based approach to education has great potential for helping students develop many general educational skills. In articles (Byrch et al., 2015; Morioka et al., 2006) has laid out the initiatives to contribute to global sustainability through reform and streamlining of the current technological paradigm and business. This reform is based on a future-oriented and global approach. In this initiative, industry and business plays a critical role as a link between technology, business and society. Leicht et al. (Leicht et al., 2018) presents an overview of ESD and highlights key issues related to ESD policy and practice. Topics include key ESD competencies and themes, policy, changes in the learning environment, teacher training, youth as lead actors, scaling-up action, and the monitoring of progress.

The epidemics, the destruction of the natural environment and climate change, the depletion of material and energy resources, the population explosion and lack of food, as well as the civilization crisis as a whole, are complex interdisciplinary problems of the humankind. New directions of science appear for their solution. The convergence of methods and interdisciplinary approaches is the main characteristic of these advanced scientific communities.

Supra-sectorial technologies (information, cognitive, nano-, bio-, social technologies) are currently actively developing. Thanks to them, new branches of science appear and serve as a new methodological basis for studying nature (Arshinov et al., 2011; Ahromeeva et al., 2013; Kovalchuk, 2011). Such interdisciplinary scientific fields lead to new directions in science such as risk management, sustainable development, new nature management, etc.

The quality of professional training of students in the modern sense determines their readiness and ability to use the acquired professional competencies to solve not only professional tasks, but also multidisciplinary tasks. Solving such problems contributes to sustainable development at the level of the country, region and the world as a whole. This implies updating the content and methods of professional training of specialists at a modern university taking into account the requirements of interdisciplinary integration and the implementation of sustainable development ideas (Shults and Tsyiganov, 2010; Solodova and Malinetskiy, 2013).

The work (Chekmarev, 2014) emphasizes that the competitive professional competence of university graduates in the labor market in the light of international requirements can be achieved subject to significant changes in the system of higher professional school. The articles (Sirenko, 2014, 2013) presents the ways of enriching the content of the academic discipline “Fundamentals of Information Technologies” with interdisciplinary components. The diffuse principle of penetration of general scientific and philosophical knowledge into the content of the academic discipline is substantiated. The characteristics of generalized tasks as a means of interdisciplinary integration are given. The results of experimental work on checking the effectiveness of the method of using generalized problems are analyzed.

Interdisciplinary integration in higher education institutions has to be an important component of introducing sustainable development ideas into the training of modern specialists. The problems of sustainable development itself are multidisciplinary.

Such integration will solve the significant contradictions of education, namely the contradiction between the vast knowledge and limited human possibilities. The optimal combination of computer science and other academic disciplines within the same topic will provide conditions for a significant increase of the level of the educational process.

Jurgena and Cedere (Jurgena and Cedere, 2018) concluded that students have a large non-used potential to understand more deeply the nature of science and acquire the knowledge important for their future lives and work. Recently, a lot of talk has been going on about the transition to a knowledge-based society. Knowledge management systems are evolving and knowledge management professionals are employed in large corporations. Unfortunately, in the discussions of this topic higher education is not considered (Kumar and Agrawal, 2011; Boca and Mukaj, 2016). This is unacceptable, because knowledge is created, systematized and accumulated in universities, and then passed on to the next generation of people.

The learning process is the management of the process of student’s knowledge accumulation and systematization. Only a few researchers focus their attention on this fact (Martins et al., 2019; Fazey et al., 2013; Sanguankaew and Ractham, 2019; Vlasenko et al., 2021). An automated learning environment based on semantic knowledge networks is largely capable of solving a wide range of knowledge management tasks at the university. A feature of the modern stage in the development of educational systems is the necessity of expending the use of formal methods for presenting knowledge and organizing the learning process. The achievements of cybernetic, synergetic and the theory of artificial intelligence are the basis of these scientific directions. Many objects of cognitive research are networks. Alternatively, you can imagine them like that.

In the 1940s, scientists who study the human brain hypothesized that its unique properties are due not to the characteristics of individual nerve cells, but to the structure of the connections between them (Semerikov et al., 2018). To date, research on networks of a very different nature – biological, physical, social and economic – has been collectively called network science, or the science of networks.

Over the past two decades, many studies have focused on the network science methodology as an extensive scientific field of studying complex systems (for example, (Malineckiy, 2013; Barrat, 2008; Soloviev et al., 2016; Liu et al., 2010)). Complex systems contain several components that interact with each other, producing complex behaviour.

The human brain and the cognitive processes occurring in it are an example of a complex system. These processes provide memory and language (for example, (Sporns, 2011; Baronchelli et al., 2013; Beckage and Colunga, 2015; Jones, 2016; Solé et al., 2010; Wulff et al., 2019; Boccaletti et al., 2006; Borge-Holthoefer and Arenas, 2010)). The foundation of network science is mathematical graph theory. It is contains powerful quantitative methods for studying systems such as networks (for example, (Carrington et al., 2015)).

At this stage in the development of the education system, the priority is to find ways to improve the learning process, its content and structure. Receiving a fundamental and holistic education can be only as result of the learning process at the level of new quality. In this case, the content of various disciplines should reflect the logic and structure of knowledge ties between disciplines. In the absence of intersubjective communications, the knowledge will be fragmentary, unsystematic. Cognitive networks are not only a tool for cognition, but can also a basis for controlling student's knowledge.

In different historical periods, many variants of semantic knowledge networks that take into account the specifics of intellectual activity have been created. In the "precomputer era" the prototype of semantic knowledge networks was used to formalize logical reasoning. At the beginning of the twentieth century, in psychology, graphs were first used to represent hierarchies of concepts and inherit properties, model human memory and intellectual activity. In the early 60-s the first machine implementations of semantic networks were made. One of the first systems of practical importance (Masterman, 1961) contained 100 primitive types of concepts for solving the problem of automatic translation. Dictionary of 15 000 concepts was defined.

At present, semantic knowledge networks are widely used in solving many different problems, in particular when building knowledge bases, in problems of machine translation and processing of text in a natural language. Due to the wide range of use of such graphs, there is a need for their refinement – an increase in the number of nodes and an increase in the connectivity between them.

Actual modern studies are devoted to the use of semantic networks in the field of education. For example, in the work (Xie et al., 2015) the interdisciplinary of applied mathematics is quantitatively analyzed by using statistical and network methods on the corpus PNAS 1999–2013. Czerkawski (Czerkawski, 2014) discusses the potential Semantic Web for teacher education.

Dunn (Dunn, 2013) presents a theoretical method for the integration of semantic knowledge network utilization into the classroom. This paper will also introduce insights from Cognitive Linguistics as to how the brain best learns vocabulary. The method of Dunn (Dunn, 2013) springs from the fields of psychology and neuroscience as well as inspiration from educators who are building new teaching styles. The purpose of the method detailed in this paper is to inspire other educators to incorporate cognitive linguistic insights into their classes as well as further the discourse on integrating this field into the teaching of English as a second or foreign language.

Teng et al. (Teng et al., 2012) formulate recipe recommendations using ingredient networks. Researchers have shown how information about cooking can be used to glean insights about regional preference sand modifiability of individual ingredients, and also how it can be used to construct two kinds of networks, one of ingredient complements, the other of ingredient substitutes. These networks test which ingredients work well with each other and which ones are better to replace. Allows you to predict which of a pair of related recipes will work best for the user.

Traditionally, researchers formed networks of semantic knowledge manually. This is labour intensive. Such networks contain a small number of nodes, but they have an important advantage - they are checked manually. An alternative approach is the automatic construction of a semantic network based on an external source generated by Internet users (Zesch et al., 2008). A striking example of such a source is the Wiktionary (Wiktionary Statistics, 2020).

In (Kiv et al., 2014) a new stylistic-mathematical approach (SMA) for analysis of translation works was introduced. It was postulated that the important requirement to translation is its compliance with the language in which the translation was done from the point of view of Zipf's laws and information characteristics. According to SMA any translation should satisfy at least to the following requirements:

- The sense of the translation version must exactly reflect the intention of the author of original text.
- It is necessary to find the equivalent constructions in the translation version for idioms and other specific expressions in the original text.
- The translator should reach the appropriate difference between Zipf's constants for the original text and for the translation.

A computer program for application of Zipf's Laws was developed for analysis of English and Russian literary texts. This program uses the algorithms of texts data processing from the Microsoft products, such as Microsoft C#, Microsoft SQL 2008. The Microsoft SQL 2008 was chosen because it is enough powerful full-text modules, realized on more than 10 languages, The algorithm realized in the developed program allows processing any texts in order to present them as tables of database with necessary parameters. As a result of uniting capabilities of these products, the client-server structure of the program, where the program is a client and Microsoft SQL2008 is a server was obtained. The user enables to specify a set of search criteria. The program gets the answers and outputs from the server in the comfortable to user form.

This program was applied to compare different translations of the famous play of William Shakespeare "Hamlet. Prince of Denmark" (Shakespeare, 1985). Various characteristics of this work given by critics were accounted. They analyzed these translations from the point of view of the exact reflection of Shakespeare's ideas, preservations of original thoughts, and the quality of the translation language. Then Zipf's constants were estimated for the original text and translations taken from (Shakespeare, 1985) (Edition of 1828). In table 1 one can see the obtained results.

We see that table 1 Zipf's constants are varied from 0.0954 (that is close to English language) to 0.0684 (that is close to Russian language). On the basis of these results and semantic analysis performed by other researchers it was come to conclusion that the translation of Pasternak satisfied the conditions of the high level translation described above. His translation is the most closely to the native Russian language. At the same time in this translation Pasternak reproduced the music and the spirit of Shakespeare's masterpiece (Shakespeare, 1985). The opposite translation approach we see in the Radlova's translation. She tried do not omit any word in the original text. As a result she did not reproduce in Russian version the sense of Shakespeare's work and her text is closer to the structure of English language.

Thus, all of these works are devoted to the integration of semantic knowledge networks in teaching. The increasing information volumes of the educational material of the disciplines dictate the need to use cognitive modelling to solve complex problems of training and teaching.

2 MATERIALS AND METHODS

There are various ways of representing knowledge, in particular, such visual methods for describing knowledge in the subject field: semantic networks, graphs of conceptual dependencies, scripts, frames, conceptual graphics and ontology.

Ontologies are an effective means of representing and organizing knowledge. For the formal specification of concepts and relationships, researchers use ontologies. Ontologies characterize a specific subject area. Ontology consists of terms (concepts), their definitions and attributes, as well as associated axioms and inference rules.

Formally, ontology is a relation:

$$O = < T, R, F >,$$

where T – concepts (terms) of the subject area described by the ontology O, R – relationship between terms of the subject area, F – functions of interpretation, given on terms and relations of the ontology.

Let us determine the definitions that are important for this work: "semantic knowledge network", "semantic network", "network model", "cognitive map", "cognitive network", "cognitive scheme". Figure 1 shows a diagram of the types of cognitive schema.

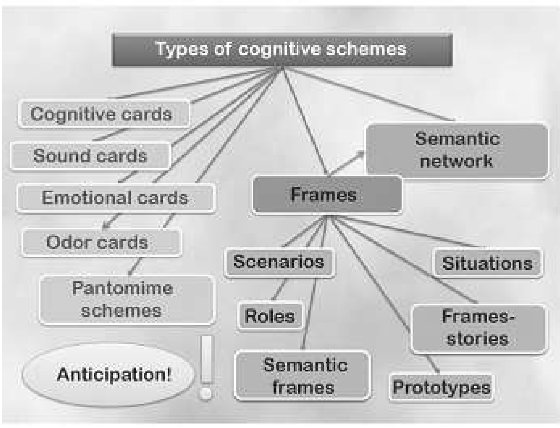

Figure 1: Cognitive scheme type chart.

Cognitive maps are a concept of cognitive psychology pioneered by Tolman (Tolman, 1948). A cognitive map is an active, information-seeking structure.

Table 1: Zipf's constants for different translations of "Hamlet. Prince of Denmark".

Author and translators	**Year**	**Zipf's constant**	**Comments**
Shakespeare	1603	0.1191	Original
Pasternak	1940	0.0684	Translation
Romanov	1899	0.0882	Translation
Averkiev	1895	0.0827	Translation
Kroneberg	1925	0.0837	Translation
Lozinski	1933	0.0877	Translation
Radlova	1937	0.0954	Translation

In our work, the concepts of "semantic knowledge network" and "semantic network" are identical.

In cognitive science, the network is one of the most common types of information models. Typically, a network consists of two components – nodes as network elements and edges, reflecting the interaction between the elements. Using these simple components, you can describe a wide range of objects of different nature and complexity. The network concept is the foundation of network models. In such models, all relationships are clearly distinguished. These relations constitute the framework of knowledge of the subject area, the model of which must be created. This class of models includes semantic networks, functional networks, and frames (frame representation).

Although the terminology and structure are different, there are similarities inherent in almost all semantic networks:

- Different nodes of one concept belong to different values, if not it is marked that they relate to one concept.
- Edges of semantic networks create relationships between concept nodes (marks above arcs indicate the type of relationship).
- Relations between concepts can be linguistic cases, such as "agent", "object", "recipient" and "instrument" (others mean temporal, spatial, logical relations).
- The concepts are organized by level in accordance with the degree of generalization.

An associative approach to knowledge representation defines an object value in terms of its connections (associations) with other objects. Thus, when a person perceives an object and discusses it. At this time, the brain maps the object of perception into a certain concept (figure 2 (Babkin et al., 2006)). This concept is part of general knowledge about the world. Therefore, it is associated with various associations with other concepts. Associations define properties and behaviour of the perceived object.

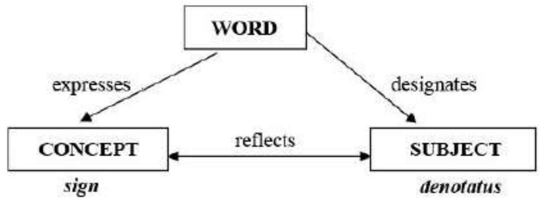

Figure 2: The relationship of the concept, subject and word denoting this subject (Babkin et al., 2006).

Scientists have developed semantic networks within a scientific field that relates to the representation of knowledge to model human thinking. This area of research has arisen within the general problem of artificial intelligence. It focuses on the development of specialized languages and graphical tools for representing declarative or static domain knowledge. The results of research in the field of semantic networks have been refined and successfully used in the construction of conceptual models and relational database schemes.

Semantic networks are the most powerful mathematical model for representing knowledge about a subject area, one of the most important areas of artificial intelligence. Currently, the scientific literature describes many alternative representations of semantic network models. Researchers use them to solve a variety of problems in a variety of software.

In general, a semantic network is an expression:

$$S = (O, R_1, R_2, \ldots, R_k),$$

where O is a set of objects of a specific subject area, $R_i | i = 1 \ldots n$ is a set of relationships between objects, i is the type of relationship.

In the general case, a semantic network is understood as a certain graph $G_s = (V_s, E_s)$, in which the set of vertices V_s and the set of edges Es are divided into separate types that have special semantics characteristic of a particular subject area. In this situation, the set of vertices can correspond to objects or entities of the considered domain and have the corresponding explicit names of these entities instead of the vertex numbers. Such names should allow unambiguous identification of the corresponding objects,

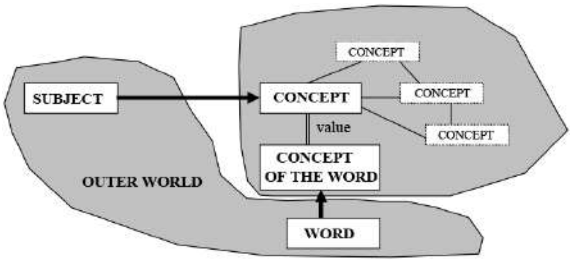

Figure 3: The relationship of various concepts in the human mind (Babkin et al., 2006).

while there are no general formal rules for recording names. There are also different types of edge sets that correspond to different types of relationships between entities in the area in question.

Many real-world phenomena can be modelling with the help of a graph. For example, we can think of various web pages as nodes and hyperlinks as directed edges to represent the World Wide Web as a graph. For instance, we can view various web-pages as nodes and hyperlinks as directed edges to represent the World Wide Web as a graph. Such a modelling can help perform various graph computations on the web. For instance, PageRank algorithm is a popular graph algorithm, which is used to rank the web-pages. Alternatively, the web-graph can be used to find clusters of web-pages, which link one another. This can help in categorizing the web-pages into various topics (Cheramangalath et al., 2020).

Graphs are best suited for explicitly expressing associations between different concepts. Thus, in the form of a semantic network, knowledge of the world is expressed. A semantic knowledge network is a marked graph in which nodes correspond to certain facts or general concepts, and edges mean relationships or associations between different facts or concepts (figure 3 (Babkin et al., 2006)).

In each academic discipline (in every science) the number of concepts reflecting the knowledge of this discipline (this science) is finite. There are a number of words that need to be conveyed to the audience. The number of these words is not infinite, because time for their transfer is limited. Textbooks establish linear links between concepts.

A normalized description of knowledge networks can be formulated as follows. The body of knowledge of the studied discipline is a system (*S*). The elementary component that is part of *S* is a word that reflects a certain concept. With the help of words, all the concepts that make up the *S* system are recorded. Links between the concepts are established using the grammatical rules of a particular language. With respect to each concept from *S*, there is a primary sentence that contains its definition. The totality of such definitions forms an invariant kernel *S*, which ensures the unambiguity of the perception of knowledge within a particular academic discipline. The invariant core of the discipline uses words from other areas of knowledge to determine its concepts. All concepts from *S* are divided into main and auxiliary. The basic concepts include specific concepts of this particular discipline, which are the subject of its definition and study. Supporting concepts include concepts borrowed from other areas of knowledge that are not studied in this discipline, but are used to determine the content of basic concepts. Many of the basic concepts of a particular discipline, together with the internal relationships between them, form a hierarchically ordered network of knowledge, the nodes of which are the identifiers of the basic concepts.

Thus, the knowledge system can be represented in the form of a hierarchical directed graph – a semantic knowledge network.

The semantic knowledge network building algorithm involves several steps:

(1) Writing all the basic terms of the subject area and formulate their definitions (composing the thesaurus of the subject area).

(2) Selecting the terms from the list that appear in the definition of the other terms listed in step 1.

(3) At the lower (I) level, arranging the terms in the definition of which the terms from the list are not used.

(4) At the next (II) level, arranging the terms in the definition of which the terms of level I are used.

(5) At the III level – terms in the definition of which the terms of I and II levels are used, etc.

(6) At the last level, arranging terms that are not used in the definition of other terms.

(7) Connecting the concepts.

Visualization of data in a structural network model is the first step, but the strength of the method lies in the ability to extract important knowledge about the system through a statistical analysis of the network topology. It seems that topology bears an evolutionary imprint and functional (Barabási, 2012). A detailed analysis of the available metrics can be found, for example, in (Barabási, 2016). Consider just a few metrics often used in cognitive model research.

Let us consider in detail the network structure. A network consists of nodes and links between them, edges. Nodes are more or less stable entities that do not change over time.

Edges represent relationships, interactions, transactions, or any other temporary connections that occur between nodes over a certain period of the time.

Edges represent connections between them: friendships, proximity, transactions, exchanges and any other temporary connections between stable objects that occur with a certain frequency.

Edges are important to network analysis because they represent the connectivity basis that will be using to get insights about the complexity network. In a graph database, the relationships between the data are just as important as the data itself.

Giant component is an important notion in network analysis. It's an interconnected constellation that includes most of the nodes in a network.

Clusters are the constellations of nodes that are more densely connected together than with the rest of the nodes in the network. Clusters represent different sub networks within a network and can be used to identify various subcategories that are present within.

In modern network theory, the number of node connections (in the theory of graphs, nodes and nodes are edges and vertices of a graph, respectively) is called a degree. A node's degree indicates how many connections it has to the other nodes in the network. The more degree a node has, the more "connected" it is, which indicates its relative influence in the network.

The concept of degree is a local characteristic of a graph. A nonlocal, integral network structure is defined by two concepts – a path and a loop or cycle. A path is a sequential sequence of adjacent nodes and the links between these nodes when the nodes do not repeat. A loop or cycle is a path when the start and end nodes coincide. Networks without loops are trees. The number of nodes (N) (network size) and the number of links (L) are related as $N = L - 1$ (Soloviev et al., 2016).

Identifying the nodes with the highest degree (also called "hubs") is an important part of network analysis as it helps identify the most crucial parts of the network. This knowledge can then later be used both to improve network's connectivity (by linking the hubs together) and disrupt it (by removing the nodes).

Betweenness centrality is another important measure of the node's influence within the whole network. While degree simply shows the number of connections the node has, betweenness centrality shows how often the node appears on the shortest path between any two randomly chosen nodes in a network. Thus, betweenness centrality is a much better measure of influence because it takes the whole network into account, not only the local connectivity that the node belongs to.

A node may have high degree but low betweenness centrality. This indicates that it's well-connected within the cluster that it belongs to, but not so well connected to the rest of the nodes that belong to the other clusters within the network. Such nodes may have high local influence, but not globally over the whole network.

Alternatively, other nodes may have low degree but high betweenness centrality. Such nodes may have fewer connections, but the connections they do have are linking different groups and clusters together, making such nodes influential across the whole network.

In network visualization, we often range the node sizes by their degree or betweenness centrality to indicate the most influential nodes.

Network topology is an important element of network analysis. If we analyse networks on the structural basis we will discover many differences among them. A tool for studying complex networks based on graph theory is topological analysis.

When performing network analysis and visualization it is important to classify the topology of the network (Gephi, 2020a). This can be done through quantitative analysis of degree distribution among the nodes and/or through qualitative analysis using various visual graph layouts.

Degree distribution can be a good indicator of the network's topology. If most of the nodes in the network have exactly the same degree, the network is more of a regular one (it may also indicate the presence of tree-like hierarchical system within the network). If most of the nodes have an average number of connections that is the same and then some of the nodes have more and some of the nodes have less (normal bell-curve distribution of degree), we're dealing with a randomized network. Finally, if there's a small, but significant number of nodes with a high degree and then degree distribution follows a long tail towards a gradual decline (scale-free distribution), this is a small-world network, where there's a significant amount of well-connected hubs, which are surrounded by less connected satellites, which form clusters. Those clusters are connected to one another via the hubs and the nodes that belong to several communities at once.

Graph layout a qualitative measure for identifying topology of a network. A very useful type of layout is Force Atlas, where the most connected nodes with the highest degree are pushed apart from each other, while the nodes that are connected to them but have lower degree are grouped around those hubs. After several iterations this sort of layout produces a very readable representation of a network, which can be used to better understand its structural properties and identify the most influential groups, differences between them, and structural gaps within networks.

Network motifs are the different types of constellations that emerge within network graphs. They can provide a lot of useful information about the structural nature of networks.

For example, some networks may be comprised of diads or pairs of nodes (which indicates that the level of overall connectivity is quite low). Some other networks can have a high proportion of triads, which usually indicate the presence of feedback loops, which makes the resulting network formations much more stable. More complex formations include groups of four nodes that can be connected as a sequence or between each other, forming interconnected clusters that can encode certain levels of complexity that go beyond simple triad feedback constellations.

It is important to take notice of the network motifs that emerge within a network because it will provide a very good indication of the level of complexity and thus the capacity of the network.

Modularity is a quantitative measure that indicates the presence of distinct communities within a network. If the network's modularity is high, it means it has a pronounced community structure, which, in turn, means that there's a space for plurality and diversity inside. If the modularity is too high, however, it might also indicate that the network consists of many disconnected communities, which are not globally connected, making it much less efficient than an interconnected one.

Modularity works through an iterative algorithm, which identifies the nodes that are more densely connected to each other than to the rest of the nodes in the network. It will then calculate the measure of modularity for the network at large. The higher this measure is, the more distinct those communities of densely connected nodes are. If the modularity measure is 0.4 or above it means that, the community structure in the network is quite pronounced. If it's less it means that there are no big differences between the different clusters and most of the nodes are equally densely connected to each other across the whole network.

So far we've looked at the different measures of connectivity that exist within networks and that help us identify the most influential nodes, clusters, and deduce some basic functional properties of the networks we study.

However, one of the most important aspects of network graphs is that they also let you see the gaps, empty blank spaces, between the islands. Those gaps are usually referred to as "structural gaps" and it has been shown that bridging those gaps can spur innovation, create most interesting collaborations, and give rise to new, unexpected ideas.

In other words, "structural gaps" is where creativity and potential is hidden within the network. Therefore, when visualizing a network it is important to identify those structural gaps and to devise different actions that could help bridge different nodes and clusters across those empty spaces within the graph in order to spur creativity and innovation.

3 RESULTS AND DISCUSSION

A study of the dynamics of the popularity of the term "network science" from 2004 to 2020 using Google Trends (Google, 2021), carried out at the time of writing this manuscript, showed a steady trend (figure 4). Of queries, which hold an average of about 80 conventional units, while the mark 100 corresponds to the largest volume of requests.

As an example of modeling semantic knowledge networks, we analyze the relationship between the concepts of academic disciplines. As you know, that discipline mastering is closely connected with the assimilation and comprehension of the course concept thesaurus. To assimilate further concepts within the framework of this discipline, it is necessary to understand the already learned, often in the framework of the already studied disciplines. Therefore, an actual task is to study the dependencies between concepts and to model them, using cognitive networks (Gephi, 2020a).

The figure 5 shows a fragment of the construction of a semantic knowledge network.

To implement the subject area model in the form of a semantic knowledge network, we propose the following algorithm:

(1) Classification of all concepts of the subject area into macro concepts (class of concepts), meta-concepts (generalized concepts) and micro-concepts (elementary concepts).

(2) The allocation of common properties, characteristics inherent in each level of concepts.

(3) Highlighting the hallmarks of each level of concepts.

(4) Establishing links between concepts related to the same level.

(5) The allocation of inter-level ties.

We have analysed 125 concepts that are necessary for the "Economic Cybernetics" discipline mastering and the relationship between them (communication means the need for one concept to master another). We conducted a similar study for 125 concepts of the

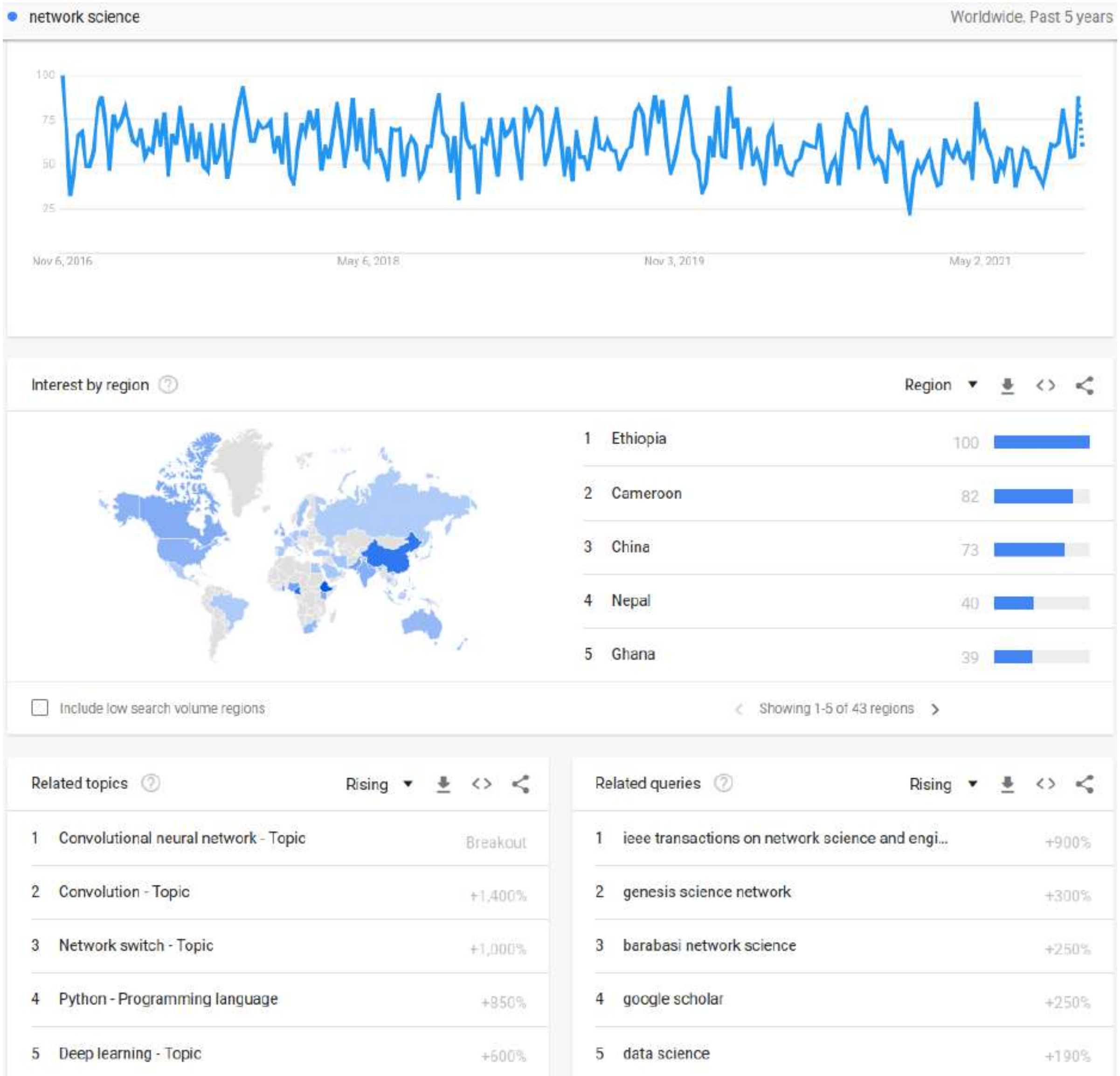

Figure 4: Dynamics of the popularity of the query “network science” in Google Trends (Google, 2021).

“Algorithmization and Programming” and 125 concepts of the “Mathematical Analysis” discipline.

There are many systems used by analysts (mainly researchers), both for visualizing network structures and for performing computations. At the time of this writing on Wikipedia (Wikipedia, 2021), we have counted 89 links to various programs for analyzing complex networks. To select the most popular programs, we turned to the analysis of software tools that are used by the world’s leading universities (Gephi, 2020b; iGraph, 2021; NetworkX, 2021; SNAP, 2021). These can be ready-made products with a user interface and a set of implemented functions, as well as libraries of computational methods. Some systems developed for scientific research are briefly described in the table. All considered systems, except Gephi, do not have a user interface and are simply libraries of computational functions for analyzing and visualizing graphs (table 2).

After a comparative analysis, the results of which are presented in the table, the obtained graphs were visualized using the Gephi software product (Yevin, 2010). Gephi is free open-source, leading visualization and exploration software for all kinds of networks and runs on Windows, macOS, and Linux. It is highly interactive and user can easily edit the node/edge shapes and colors to reveal hidden patterns. The aim of the Gephi is to assist user in pattern discovery and

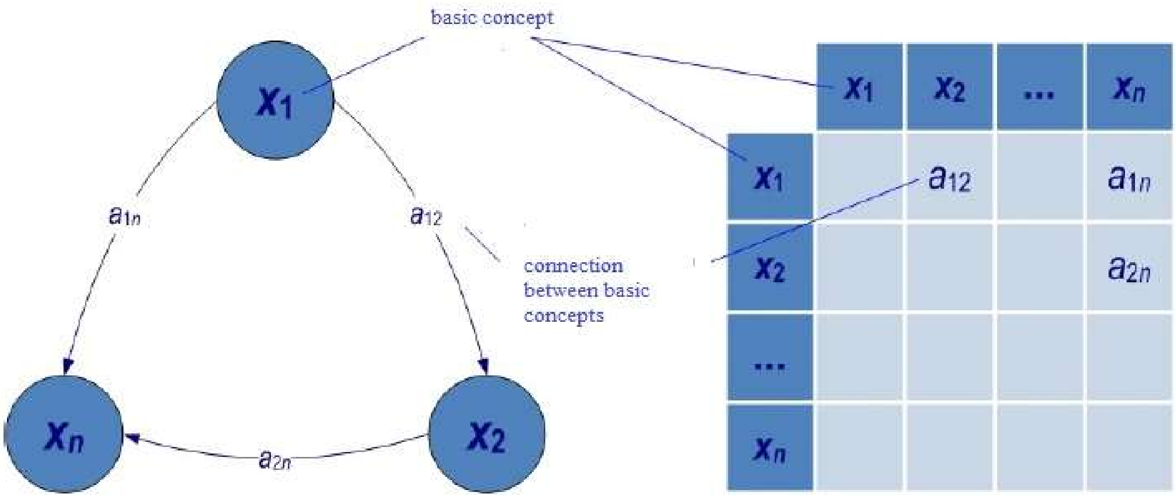

Figure 5: The semantic knowledge network diagram.

hypothesis making through efficient dynamic filtering and iterative visualization routines.

Gephi allows to calculate the topological characteristics of the graph, as:

- Nodes and edges (what networks are made of).
- Clusters (groups of nodes that are connected).
- Degree (the number of connections that the node has).
- Centrality between (how influential a node is).
- Modularity (community structure).

Gephi comes with a very fast rendering engine and sophisticated data structures for object handling, thus making it one of the most suitable tools for large-scale network visualization. It offers very highly appealing visualizations and, in a typical computer, it can easily render networks up to 300 000 nodes and 1 000 000 edges. Compared to other tools, it comes with a very efficient multithreading scheme, and thus users can perform multiple analyses simultaneously without suffering from panel "freezing" issues.

In large-scale network analysis, fast layout is a bottleneck as most sophisticated layout algorithms become CPU and memory greedy by requiring long running time to be completed. While Gephi comes with a great variety of layout algorithms, OpenOrd (Martin et al., 2011) and Yifan-Hu (Hu, 2005) force-directed algorithms are mostly recommended for large-scale network visualization. OpenOrd, for example, can scale up to over a million nodes in less than half an hour while Yifan-Hu is an ideal option to apply after the OpenOrd layout. Notably, Yifan-Hu layout can give aesthetically comparable views to the ones produced by the widely used but conservative and time-consuming (Fruchterman and Reingold, 1991). Other algorithms offered by Gephi are the circular, contraction, dual circle, random, MDS, Geo, Isometric, GraphViz, and Force atlas layouts. While most of them can run in an affordable running time, the combination of OpenOrd and Yifan-Hu seems to give the most appealing visualizations. Descent visualization is also offered by OpenOrd layout algorithm if a user stops the process when 50–60% of the progress has been completed. Of course, efficient parameterization of any chosen layout algorithm will affect both the running time and the visual result.

The constructed graphs (figures 6–8) can be used to identify the most important concepts that have the highest degree of apex, as well as concepts that are in the way of studying other important course concepts. In figures 6, 7 and 8 the size of the nodes-concepts of semantic knowledge networks characterizes the degree of importance and fundamentality of the corresponding terms of the academic discipline.

The table 3 shows various metrics and methods for calculating them. For the obtained graphs, their topological characteristics were calculated and analysed. The results of the study are shown in table 4.

Let us analyse the found values of measures (table 4). The Network Density measure is a measure of the density of edges, calculated as the ratio of the number of edges of a graph to the corresponding number of vertices and determines the maximum number of edges in a given graph. Thus, the values 0.17 – for the graph of discipline "Economic cybernetics" and 0.2 – for the "Mathematical Analysis" means that the edges are filled with about 17.3% and 19.5% of the maximum possible respectively. The density of the

Table 2: Comparative characteristics of systems for analyzing network structures.

	Gephi	**Igraph**	**NetworkX**	**SNAP**
Website	gephi.org	igraph.sourceforge.net	networkx.lanl.gov	snap.stanford.edu
Users	Scientific, Educational Organizations			
Data Volumes	Up to 1 million nodes and edges	Up to several million nodes and edges		
Data Collection	None			
Data Sources	None			
Analysis Mode	Retrospective Analysis			
Methods	Visual Analysis, Basic Statistical Methods, Basic Methods of Graph Theory	A wide range of graph theory methods		
Objects Considered	Network structure (nodes, directional and non-directional links)			
Distribution Terms	OpenSource (CDDL 1.0, GPL 3.0)	OpenSource (GPL 2.0+)	OpenSource (BSD License)	
Language support	English			
Developer	Gephi Consortium (more than 10 organizations). USA, France, Germany, etc.	Gábor Csárdi (Harvard University, USA), Tamás Nepusz (Eötvös University, Hungary)	AricHagberg, Dan Schult, Pieter Swart and others	Stanford University
Clients	Used in research projects, data visualization and educational programs.	Used in research projects	Scientific organizations	Used in research projects, in particular by Stanford University

graph of concepts of the discipline “Programming” is less: 11%, which can be explained by a smaller number of connections between concepts on average in the graph.

The maximum degree of 121 vertices was demonstrated by the concept graph in the “Programming”. The maximum value of the degree of the vertex in the column “Economic cybernetics” – 111. The minimum degree of vertices in the graphs “Economic Cybernetics” and “Programming” are 3 and 1, respectively, which are almost the same. For “Mathematical Analysis”, the number of weakly connected nodes is higher – 7, and strongly connected – 113, which is less than in “Programming”, but more than in “Cybernetics”.

It also confirms a greater connection between the concepts of the “Economic cybernetics” and “Programming” than the concepts of the “Mathematical Analysis”.

Mean average node degree for the “Economic Cybernetics” graph is 21.45, and for the “Programming” graph – it is 13.66 and for the “Mathematical Analysis” – 24.18. This is confirms the presence of more connections in the last graph.

The global clustering coefficient (clustering) for a graph is the ratio of the number of vertically connected triples of vertices to the number of triangles (cyclically connected triples of vertices). For the “Economic Cybernetics” graph, the clustering coefficient is 0.4, for the “Programming” graph – it is 0.33, and for the “Mathematical Analysis” – 0.59. This means that the concepts of the “Mathematical Analysis” course are more often on the path to mastering other important concepts.

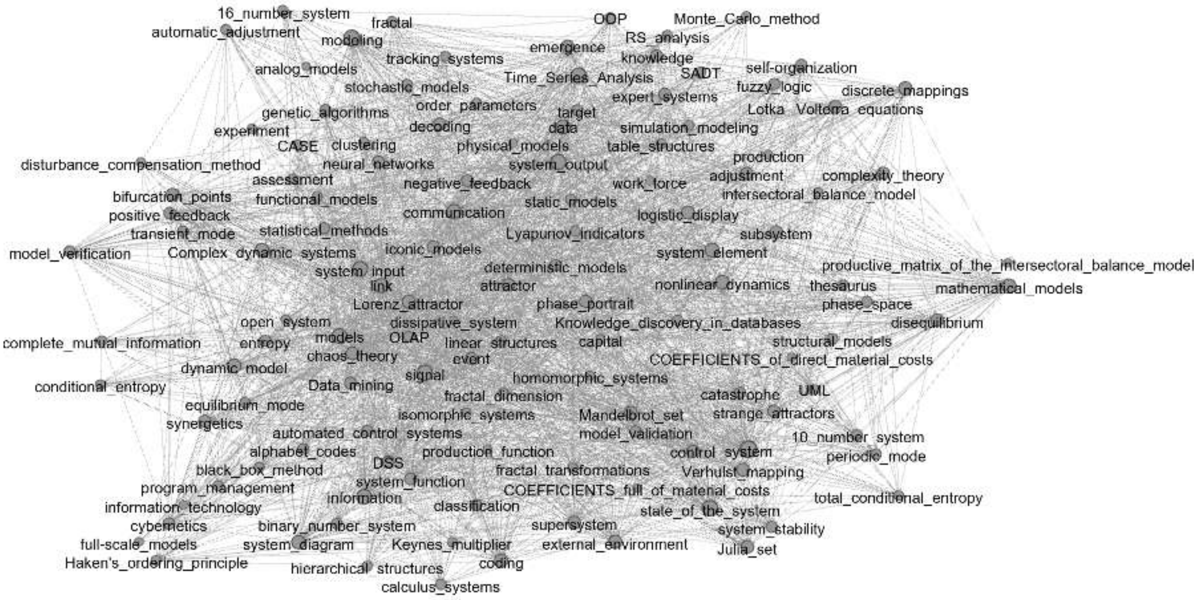

Figure 6: The semantic knowledge network of the course concepts “Economic Cybernetics”.

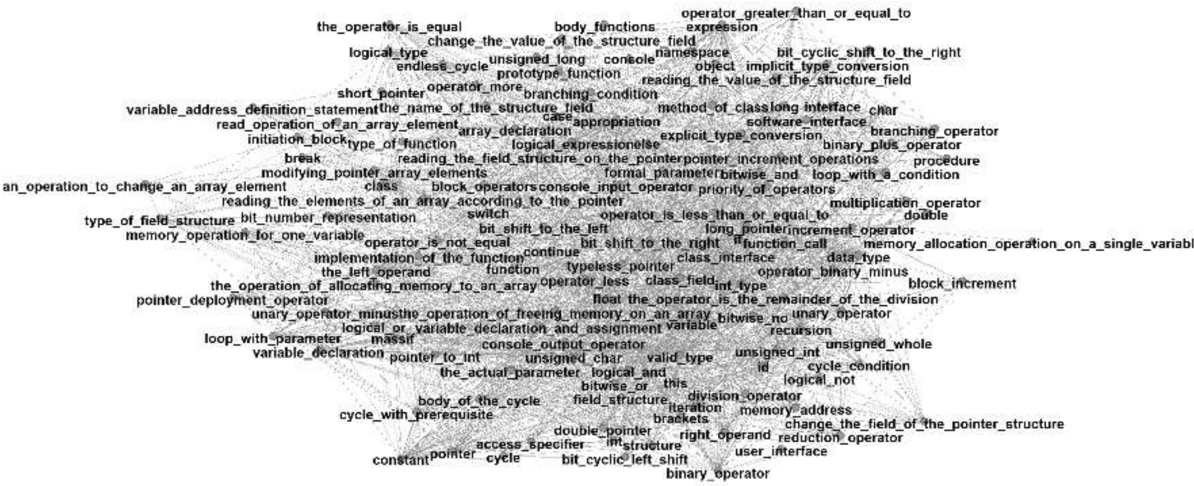

Figure 7: The semantic knowledge network of the course concepts “Algorithmization and Programming”.

As for the diameters of the graphs – for the “Economic Cybernetics” concept graph the diameter value is 5, for the “Programming” graph – 9 and for “Mathematical Analysis” – 3. The same relationships are observed for average shortest path-lengths. Which may mean the existence of longer paths in the connections between the “Programming” discipline concepts.

The modularity index is less than 0.4, which means that the structure of communities in all three networks is not sufficiently expressed.

In the field of education, there is always a problem of the contradiction between increasing the amount of scientific information and limiting the time allotted for its assimilation. Teaching academic disciplines in higher education requires constant work on educational information in order to move from extensive to intensive teaching methods. One of the ways to intensify the educational process can be the optimal “packaging” of educational information.

The solution to this problem is the construction of a semantic network. An important condition for the successful mastering of educational material is the ability of the teacher to highlight the key issues of the program. Nodal issues of the program are the basis for studying the whole topic. Their significance can be determined using a graph or adjacency matrix.

For example, let a topic contain 6 questions and the logical connections between them are presented

Table 3: Metrics used for network analysis in Gephi.

Metric	How calculated
Nodes	Nodes contain discipline concepts. Simple count.
Weakly Connected	Number of maximally sized clusters in which each node is reachable from every other node along undirected edges.
Strongly Connected	Number of maximally sized clusters in which each node is reachable from every other node along directed edges.
Diameter	Longest finite optimal path between nodes using undirected edges.
Average Shortest Path Length	Average Shortest Path Length (along undirected edges) between all connected nodes.
Network Density	Fraction of all possible undirected edges present.
Average Degree	Average number of undirected, unweighted edges per node.
Modularity	Calculated using Gephi algorithm.
Clustering Coefficient	A node's clustering coefficient is the ratio of the number of actual connections between the node's neighbours, to the number of the maximum potential connections between those neighbours. The network's clustering coefficient is the average of the clustering coefficients for all the nodes.

Table 4: Comparison topological characteristics of the graphs of the relationship between the concepts of the disciplines: "Economic Cybernetics" (E), "Algorithmization and Programming" (P) and "Mathematical Analysis" (M).

Parameters	E	P	M
Nodes	125	125	125
Weakly Connected	3	1	7
Strongly Connected	111	121	113
Diameter	5	9	3
Average Shortest Path			
Length	2.21	3.416	1.806
Network Density	0.17	0.11	0.20
Average Degree	21.45	13.66	24.18
Modularity	0.25	0.30	0.23
Clustering Coefficient	0.40	0.33	0.59

in the form of an adjacency matrix (table 5).

The significance of the question can be characterized by the weight coefficient determined by the formula:

$$\alpha_\beta = S_i/k,$$

where S_i is the number of references to the i-th question when studying the others contained in this topic, k is the total number of questions in this section.

Table 5: Example topic adjacency matrix.

	P_1	P_2	P_3	P_4	P_5	P_6	α_B
P_1	0	1	1	0	0	1	3/6
P_2	0	0	1	1	1	1	4/6
P_3	0	0	0	1	1	0	2/6
P_4	0	0	0	0	1	0	1/6
P_5	0	0	0	0	0	0	0
P_6	0	0	0	1	0	0	1/6

The larger the coefficient leads to the greater the significance of the issue. Thus, it is possible to determine the importance of the discipline (section) in the study of all disciplines of the curriculum. A similar technique can be used in the formation of the content of academic subjects on the basis of discipline standards, in the development of curricula and tests, in the selection and organization of educational information for training.

4 CONCLUSIONS

Algorithms for the formation of a semantic knowledge network are developed. The knowledge network is the basic concept of knowledge management. In fact we introduce a new discipline that implements the principles of sustainable development of education. The method of constructing a semantic knowledge network of terms allows forming a so called adjacency matrix that reflects the correlation of terms from a terminological dictionary. This matrix allows to evaluate the quality of the terminology in the particular discipline, as well as to determine quantify the semantic connectivity of the whole tutorial. According to obtained results, we can conclude that the concept system in the "Economic Cybernetics" is connected and complex. This means that in this case when studying any concepts, it is necessary to repeat the meaning of those already studied. The concept system in the "Programming" contains fewer dependencies and less connectivity in comparison with graphs. However, the experience of studying these disciplines indicates that also the "Programming" is not easy to learn. Further the problem of planning the learning process based on semantic networks of knowledge will be studied. Namely, the distribution of lectures, practical and laboratory exercises will be determined to achieve successfully the learning objectives.

We can continue to analyse the network structure of the curriculum. The curriculum is a complex system with nodes representing courses and links between nodes, course prerequisites. The latter is easy to obtain from the course catalogue. The resulting

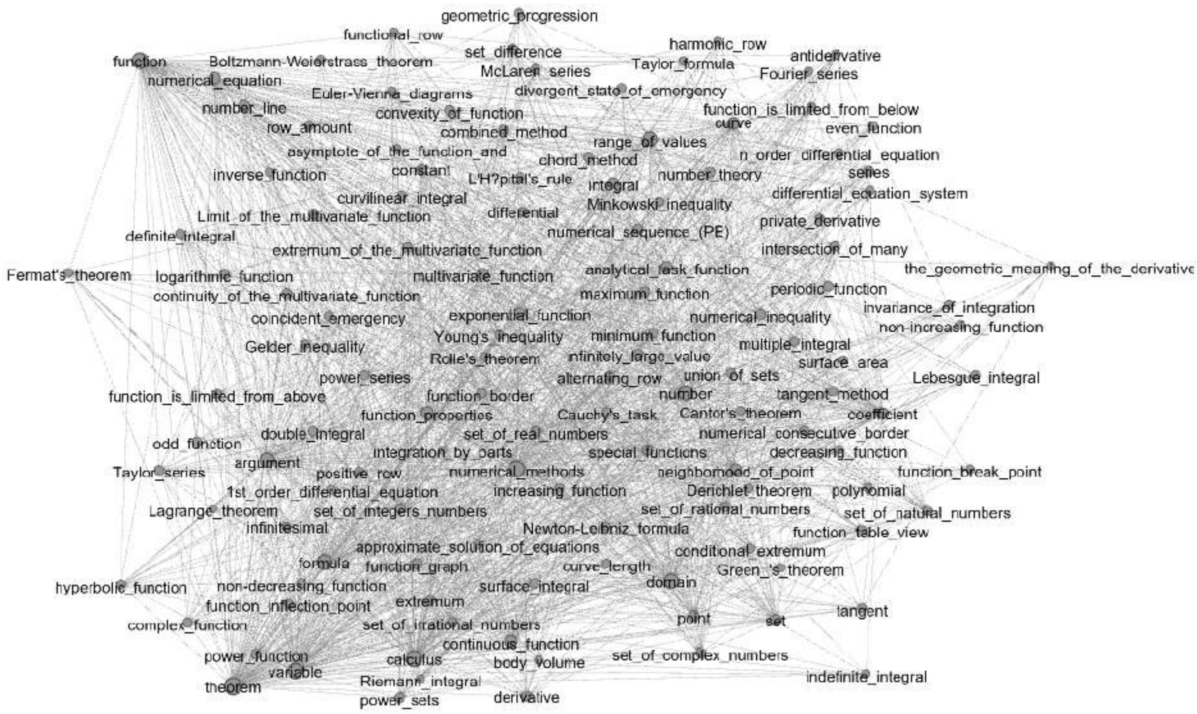

Figure 8: The semantic knowledge network of the course concepts “Mathematical Analysis”.

network of curriculum prerequisites is in the form of a directed acyclic graph. This graph has certain analytical characteristics. In future work, we will to calculate spectral characteristics of graphs for the studied disciplines, as it was done in (Soloviev et al., 2020).

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The Practical Experience of the Use of Digital Learning Resources by Ukrainian Teachers to Ensure the Sustainable Development and Democratization of Education Process

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Keywords: Digital Learning Resources, Sustainable Development, Education Process, Teachers, Democratization, Digital Competence.

Abstract: The article deals with the revealing and analysis of the practical experience of the Ukrainian teachers' use of the digital resources in the classroom activities with pupils. The online instruments and digital resources for the realisation of STEM-education, Education for Democratic Citizenship, and Entrepreneurship Education are presented in the article. The national online resources revealed in the article ensure the creation of the sustainable, multicultural, and democratic environment for teachers and students including key competencies areas: entrepreneurship, citizenship, civic education and STEM. The presented digital learning tools reveal the results of the teachers' works on the implementation of the key subject areas trough ICT and allow to creative use of digital technologies, identify teachers' and pupil' needs and finding didactic approaches, solve technical problems, identifying gaps in digital and civic competencies. Using the analysed resources teachers become aware of the need to improve and update their own digital competence and pupils' digital competence as well; ability to support the creative and sustain digital environment in their schools; search for opportunities for self-development and awareness of digital evolution that is proclaimed by the UN '2030 Agenda for Sustainable Development' adopted in 2015; the need to raise awareness how to organise distance learning in the conditions caused by COVID-19 pandemic. The objective is to present the examples and the experience of the use of digital educational resources by Ukrainian educators, which are aimed at building the digital environment, developing the key competencies: digital civic and entrepreneurship according to the European tendencies. The presented experience can be applied in the schools and improve the existing gaps in the teachers' use of digital learning tools.

1 INTRODUCTION

An urgent issue for educators all-over the world and in particular in Ukraine is the implementation of training in the context of the COVID-19 pandemic, which has led to a change of approaches to finding effective ways on how to organize the educational process in schools. Digital technologies that provide access to educational resources and forms of distance learning have come to the fore (Shokaliuk et al., 2020). Ensuring the sustainable development of education in the framework of modern educational reforms remains as an important task of the Ukrainian state (Lavrentieva et al., 2020). This task is of particular importance in the context of the European integration processes taking place in education, as well as in the context of democratization of society, and revision of the methods and content of education. A number of international education organizations have issued the responses to COVID-19, calling on governments and educators to join forces to improve the distance learning process, given the educational opportunities available in dif-

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ferent countries. The issues of digital literacy, digital competence of teachers and pupils have acquired a special role in this process (Moiseienko et al., 2020). These issues are important areas in which such international organizations as the Council of Europe, UNESCO, OECD and others are engaged. Thus the ICTs as a tool can be used by teacher, who plays an important role in these processes. The modern teacher has to follow the best European teaching practices, and in the same time to keep up with the innovations that are implemented not only in Europe but also in his own country.

Sustainable Development Goals (SDGs) are outlined in the document 'Transforming our world: the 2030 Agenda for Sustainable Development' adopted by the General Assembly of the United Nations stated in 2015 (Park, 2016). This resolution identified 17 Sustainable Development Goals including education. Goal 4 is to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

The purpose of the article is to present the current experience of the use of digital learning resources by Ukrainian teachers aimed at the promoting the development of digital competencies of their pupils as well as ensuring the democratization of learning process in the schools from SDGs perspective, and to reveal the approaches to the development of the sustainable, democratic, multicultural digital environment in the educational institutions. The research method involved the analysis of the current research and practices including Ukrainian and European experience of the use of digital resources and instruments in teachers' activities as well finding the ways of introducing innovative technology and didactic into their practice.

2 PROBLEM STATEMENTS

At the beginning of 2020, educational community in many countries was faced a challenge: the World Health Organization (WHO) declared the pandemic COVID-19 and forced quarantine, which caused the restrictions: physical access of pupils and students to educational institutions. International organizations have responded quickly to these challenges and made a number of recommendations, calling on governments to unite their efforts to harness the potential of digital technologies in school education and teacher support. The Organization for Economic Cooperation and Development (OECD) has published the Framework Guidelines for Education's Response to the 2020 COVID-19 Pandemic (OECD, 2020). Using the example of countries that were members of PISA, international organizations determined that most countries were not ready to organize distance learning.

The SDGs (Goal 4) states that by 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship. Also by 2030, substantially expand globally the number of scholarships for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes (UN, 2015). The development of pupils' digital competence is considered, today, as an integral part of educational process as a whole. The main purpose is to have an educated personality ready to live and to act into the democratic, multicultural and information society who has the necessary abilities, knowledge, skills and information culture. Attention of the teachers should be paid to the acquisition by pupils of digital skills and digital competence. The main components of digital competence include the following components: technical problem solving – the ability to identify technical problems in the operation of devices and the use of digital environments, to be able to solve them; identifying needs and finding technological answers based on needs analysis, the ability to identify, evaluate, select, use digital tools; customize digital environments and creative use of digital technologies: ability to use digital tools and technologies to create knowledge, innovative processes and products; take part individually and collectively in cognitive activities to understand and solve conceptual problems; identifying gaps in digital competence: the ability to recognize the need to improve or update one's digital competence; the ability to support others in the development of their digital competence; look for opportunities for self-development and be aware of modern digital evolution (Bakka et al., 2016).

Modern challenges of the society requires from teachers to act in the multicultural digital environment, be prepared to propose their pupils innovative ways of learning, communication, and investigation that will allow to form not only their digital skills but also prepare them to the labour market, entrepreneurship and citizenship.

The issues of development of digital literacy and competence of pupils as well as the use of information and communication technologies by teachers are revealed in the works of Ukrainian researchers (Burov et al., 2020; Bykov and Lapinsky, 2012; Morze et al., 2013; Oleksiuk et al., 2020; Osadchyi et al., 2020; Ovcharuk et al., 2020; Shyshkina, 2018; Soroko et al., 2020; Spirin et al., 2019; Vakaliuk et al., 2021; Zhaldak and Franchuk, 2021).

The article is aimed at the presentation of the diverse digital resources that Ukrainian teachers use to ensure the development of the key competencies: digital, civic and entrepreneurial as well as to reveal on how teachers support the sustainable and democratic environment in their schools using ICTs. The study of these tools by the authors led to the proposals for the Ukrainian teachers on the improvement of the existing digital educational environment regarding the challenges of the quarantine in 2020–2021 school years.

3 RESULTS

The Council of Europe is one of the international organizations that quickly responded to the COVID-19 pandemic and to the situation with the quarantine in schools in the European countries, and proposed to support digital citizenship through the creation and the support of the digital environment in schools and other educational institutions. As was noted in the CoE Multi-Stakeholder Consultation Report (Richardson and Milovidov, 2017), the educational professionals should determine the administrative and legal responsibilities of school principals, teachers, students and parents; make efforts to involve parents in initiatives of pupils and schools on digital citizenship; develop and publish lesson plans and illustrative opportunities for learning digital citizenship and create a database of the most interesting online resources; identify opportunities for the development of this area, its teaching and instilling values, views, skills, knowledge and critical understanding of the digital and real world to their pupils (EC, 2021).

To ensure the development of the democratic digital environment in the classroom the teacher should first of all take into the account the multicultural composition of the pupils. This makes it possible to include in the curriculum different discourses on the interpretation of history and geography according to a specific cultural context, mutually enriches pupils by exchanging knowledge, experiences, values belonging to different cultures, allows to use the cognitive preferences of bilingual children. The documents of the Council of Europe, the EU, the UNESCO, the UN recognize Multicultural Education as a fundamental principle that guides teachers and schools of different countries to conduct educational activities with the mutual recognition and interaction of cultures (COE, 2019).

The Multicultural Education strategy emerged in response to the exacerbation of ethnic, national, and religious conflicts in modern society as a result of significant migration processes between countries in different regions of the world. Multicultural competence and multicultural dimension in education with the use of ICT play a special role in lifelong learning today.

The Ukrainian NGO Association of Teachers of History and Social Studies “Nova Doba” invites teachers to use electronic teaching materials on intercultural interaction and multicultural education: “Common history. Dialogue of Cultures”, “Together on One Earth. History of Ukraine is multicultural”, “New approaches to historical education in a multicultural environment”, “Common stories for Europe without borders”, “Multicultural history of Ukraine”, “We are among others. Others among us. Forms and methods of multicultural education”, “Religious diversity and intercultural education”, etc. (Nova Doba, 2020). The most of the indicated resources are designed as manuals and guidelines for teachers ready to be used for different school subjects. In other hand the Multicultural Interdisciplinary Handbook created as part of an international (EU) project with the financial support of the European Commission (Comenius program) proposes a digital modules of a learning course for training future teachers of history and geography, and professional development of working teachers. The developed teaching materials help teachers to immerse themselves in the culture of other people through the study of geography and history, to motivate them to learn the foreign languages. The handbook presented online is written on six languages and can be used by all history and geography teachers interested in developing Multicultural Education in schools (García-Peñalvo et al., 2011).

The Ukrainian experience of implementing multicultural education using ICT includes an integrated e-learning course “European Studies” for pupils of the grades 8–12 on a modular basis. Course modules mix elements of multicultural education for use in lessons of geography, history, and economics (Bytsiura et al., 2004). The course is developed on the basis of the Concept of the content of education for the European dimension of Ukraine. Teacher’s manual “Media literacy in social studies lessons” provides the use of critical thinking techniques, lesson plans-summaries for teaching courses “History of Ukraine”, “World History”, “Man and the World” using electronic educational resources (Reimers and Schleicher, 2020).

The use of ICT helps to preserve pupils’ cultural identity, improves intercultural dialogue between pupils and increases their overall level of academic achievements. A special place in the development of multicultural education is given to online games (multicultural role-playing online game), that reproduce the multicultural model of the world.

Distinctive features of these games are: the ability to play at the same time for a number of players from different parts of the world; a variety of virtual worlds games are created using international English and national languages. One of the Ukrainian examples is the game that is widely used by Ukrainian teachers – "Civilization" (http://gamer-info.com/game/civilization-online/). In this game the player acts as the leader of a certain civilization (nation). It allows the participants of the game to develop science and culture, establish cities and colonies, create ways and wonders of the world, conduct wage wars and diplomatic negotiations. The game presents seven religions and cultures: Buddhism, Hinduism, Islam, Judaism, Confucianism, Taoism, and Christianity. It exists in the different languages: English, Spanish, French, German, Italian, Chinese, Russian, Japanese, Polish and Finnish.

Such games increase pupils' language and communicative competence. It should be noted that online games resources should be used wisely by the teacher, focusing on the importance of the fact that some pupils tend to overload their time in favor of computer games. It should also be borne in mind that certain online games can be a threat to students in shaping their behavior in real life. When discussing online games with pupils, the teacher must first determine their attitude to how the game takes place and ask for their assessment of game events, etc. (Ivanyuk, 2016).

The multicultural experience of communicating with representatives of other countries and cultures is of great importance for the development of multicultural competence. Therefore, one of the most effective means of forming multicultural competence is the "Culture Assimilator" method (Centre for Learning and Teaching, 2014). "Cultural Assimilators" is a training tool that includes: a brief description of situations where there is a problem of cultural adaptation or a problem related to cultural diversity between two interacting representatives of different cultures. Assimilator proposes four options for interpreting the behavior of the acting characters and explanations for each interpretation that involve discussing and determining the most appropriate answer. The methods' goal is to teach a person to consider different situations from the perspective of members of another's cultural group, to understand their vision of the world. The tasks of the cultural assimilator are the following: the acquisition of isomorphic attributions as the ways of interpretation of human behavior by representatives of other cultures; the experience of their emotional reactions in the circumstances of interethnic interactions and their correction; the formation of the tolerant behavior in a multicultural environment.

Another interesting experience is the practice of implementing STEM education and creating a digital learning environment for pupils. The Concept for the Development of STEM education adopted in 2017 proclaims the implementation of STEM at all levels of education, in establishing partnerships with employers and research institutions and their involvement in the development of this education. The training methods and training programs of STEM education are aimed at the development of competencies relevant to the labor market: critical, engineering and algorithmic thinking, skills of information processing and data analysis, digital literacy, creative qualities and innovation, communication skills etc. (Kramarenko et al., 2020)

Lozova et al. (Lozova et al., 2017) analyze the issue of creating a STEM environment in schools. They draw attention that electronic educational resources of such an environment have to meet the requirements of the intellectual and technological capacities of the pupils and should provide them by the modern integrated knowledge; to promote self-development of the individuality, to support the realization of his/her creative potential.

Stroud and Baines (Stroud and Baines, 2019) believe that to create a STEAM-oriented educational environment of the school, the electronic platform has to meet the requirements of all participants in the learning process, namely:

- the platform should provide tools for the teacher: modeling of educational STEAM-projects, creation of joint with pupils and other participants of educational process communication, support evaluation of pupils' activities in the project, creation of archive of educational projects and their results;
- the platform should provide for the pupil: feedback from teachers and other professionals involved in the educational project, free access to educational and scientific materials necessary for the project, communication with other pupils and teachers who are part of the group, tools, that can help to obtain data and test designs, models, game resources to motivate pupils to learn, virtual laboratories, etc.;
- the unregistered user should be provided by the access to open educational and scientific resources, news and announcements of STEAM-projects, instructions for using tools, including ICT, for the implementation of STEAM-projects.

Among the electronic educational resources of Ukraine that influence the active development of STEAM education are the following: the Ukrainian project “Quality of education” with the “Web-STEM-school-2020” created by Ukrainian teachers; Distance Academy (https://osnova.d-academy.com.ua/?s=STEM), that proposes the distance courses and webinars; web portal “Na urok” (https://naurok.com.ua/), proposing the distance education by the different school disciplines; virtual STEM Center of Junior Academy of Sciences of Ukraine (https://stemua.science) that offers plans and guidelines for research work for the STEM disciplines.

It should be noted that the Ukrainian teachers use such international electronic educational resources for the support and development of STEAM-oriented educational environment of the school, as: Simulate the Natural World with Virtual Biology Lab (http://virtualbiologylab.org/) which includes Ecology Models, Evolution Models, Cell Biology Models; Experience a Virtual World of Science Education (https://praxilabs.com/) which includes a number of interactive 3D virtual lab simulations in Biology, Chemistry and Physics; Phet (https://phet.colorado.edu/) which includes 806 million simulations in Physics, Chemistry, Biology, Mathematics, Earth Science; workshop for teachers for their skills development to discover and reflect on the learning benefits of playing with simulations through open play and reflection time; Physics Simulations (https://www.myphysicslab.com/), that provides open source software under the Apache 2.0 License; there are around 50 different simulations in the source code, each of which has an example file which is mainly for development and testing; Go-Lab Platform (https://www.golabz.eu/), which consists of the Go-Lab Sharing and Support platform (Golabz) and the Authoring and Learning platform (Graasp); there are around 240 teacher training events, 1800 Classroom implementations, 19152 Teachers creating spaces (20 of them are in Ukrainian language) (Dementievska, 2020).

It is important that these environments take into account the following user requirements: providing a virtual lab that allows project participants to conduct scientific experiments in the online environment; remotely controlled laboratories (remote laboratories) that allow experimenting with real equipment at a distance; virtual laboratories that simulate scientific equipment; data sets representing information from already conducted laboratory experiments (Kiv et al., 2019). The laboratories on the platforms can be combined with special programs to create conditions for other educational projects.

Regarding the actual requirements of STEM education the Ukrainian practitioners propose the online course for teachers “Creation and use the STEAM-oriented learning environment for the teachers’ digital competence development” which includes three modules: Module 1 “The STEAM-oriented learning environment for the school”, which includes the following topics: theoretical principles of creation and use the STEAM oriented learning environment for the school; creation and use strategies STEAM oriented learning environment for the school; Module 2 “Use of information and communication technologies to organize and support the STEAM approach in school”, which includes the following topics: e-Learning resources as the means of teacher’s digital competency developing to support STEAM oriented learning environment for school; electronic platform for organizing STEAM oriented learning environment for school; Module 3 “Electronic learning resources on self-assessment and evaluation of teachers’ digital competence to support the STEAM oriented learning environment for the school”, which includes topics such as requirements for assessing a teacher’s (Dementievska, 2020). The overarching goal of this course is to develop teachers’ information and digital competence, in particular, to help them to learn new information and communication technologies and to improve the quality of their teaching activities.

One of the successful Ukrainian online projects that allows to create a digital environment for pupils is the “3D Democracy” Project supported by the non governmental organization “Nova Doba”. There are few educational environments that aim to build civic competence of pupils and teachers. The NGO “Nova Doba” is the All-Ukrainian Association of Teachers of History and Social Sciences. This organisation proposes the “3D Democracy”, “Citizen’s Workshop” online environments https://citizen.in.ua/about.php. The 3D Democracy online resource aims to support teachers who teach civic education or implement its elements into the school subjects. It allows to involve pupils into the online community where they can master their civic competencies. In particular “3D Democracy” contains the following resources: “Teacher online” – is a community of civic education teachers united in a virtual educational environment; “School block” contains information about the institution that has joined the network, provides information about the educational institution on the map of Ukraine, posted on the site; “Journal of pupil achievements” that allows to provide activity of each registered pupil and to make records in the “electronic class journal” (by topics and sections); “Current information” that contains methodological materials, information about webinars, training seminars, conferences for teachers, etc.

Among the opportunities for the pupils that this resource proposes are: the online textbook / manual on civic education (texts, videos, life cases); online community for participants from different regions of Ukraine; simulations, games, polls, petitions, elections, flash mobs (on civic topics); personal offices of pupils' portfolio of civic activities; joint blogs, forums, discussions; the assessment through automatic recording of pupils' achievements (fixing student activity on each topic, a three-pronged competency approach to final the assessment of student works in each section: online testing, situation analysis, practical tasks (essays), and student motivation scale (through automatic scoring) for involvement in the activities of the "Community". Participants will receive information about the beginning of each activity and its results through: news on the site, e-mail or SMS (Nova Doba, 2020).

The Citizen Workshop resource offers tools and steps to engage with the online community. The steps to access the Citizen Workshop resource ("Community" block) are:

step 1: teacher's registration; teacher is registered as "pedagogue" at the website; teacher receives a password to access the site, in particular to the sections "Teacher's" and "Journal of Pupil's Achievement", etc. The site administrator creates a "School Block" on the site;

step 2: pupils' registration; teacher invites pupils from his / her class (s) to register. Each pupil registers on the site; pupil receives the user's personal account, password to access it;

step 3: common activity; working with materials, watching videos, life cases, simulations, games, polls, petitions, elections, flash mobs and new friends for pupils. Methodical materials, webinars, forums, discussions, experiences and new friends for teachers; For students and teachers: additional information, new friends, practical skills and first positive experiences in the field of civic activity / civic education.

The Ukrainian educational platform "Living in Democracy" is supported by the international organizations and proposes the resources of the Council of Europe teaching materials http://www.living-democracy.com.ua. It is launched as a part of the joint Swiss-Ukrainian project "Development of Civic Competences in Ukraine - DOCCU" with the assistance of the Government of the Swiss Confederation, and it offers the Council of Europe resources for education for democratic citizenship, tools for the lessons and activities on democracy, human rights and civic participation.

The platform contains educational materials, legal documents, videos, illustrated cards on children's rights, a number of textbooks of the Council of Europe in Ukrainian language including: "Teaching Democracy", "Growing in Democracy", "Living in democracy", "Taking part into democracy", "Exploring children's rights "and "Teaching democracy". Pupils, parents, teachers and school leaders can find useful information on NGO issues.They can learn, develop and improve their knowledge and civic competencies.

The DOCCU online platform presents the Swiss-Ukrainian project supported by the Government of the Swiss Confederation. It envisages the implementation of three main and cross-cutting components: Component 1 "Civil Servants". Introduction of EDC / HRE at the national level in the system of training of civil servants and representatives of local self-government bodies of Ukraine; Component 2 "School Leaders" (school principals). Introduction of Education for Democratic Citizensip and Human Rights education (EDC/HRE) in the system of postgraduate education of school principals in Kyiv, Odesa, Kherson, Poltava, Lviv, Luhansk, Ivano-Frankivsk and Dnipropetrovsk regions; Component 3 "Teachers". Introduction of EDC / HRE in the system of postgraduate teacher education in Kyiv, Odesa, Kherson, Poltava, Lviv, Luhansk, Ivano-Frankivsk and Dnipropetrovsk regions. The DOCCU online platform proposes to the wide educational community manuals and online educational resourses (video, posters) than can be used in a daily school activity.

The above mentioned examples of Ukrainian projects that use digital resources and tools serve to the teachers and to the schools as a resource of interesting interactive manuals, teaching materials, tasks for students on various topics (media, human rights, economics, socio-cultural environment, cultural diversity, identity and etc.). These digital instruments are in great demand among teachers and schools: thus, as of August 2020, the 3D Democracy community has 5,035 users, of which about 1,500 are teachers. Such indicators prove the popularity and interest of teachers in digital resource support for civic education nowadays.

In order to ensure the effective use of the STEM instruments in school practices with the pupils the professional development of teachers has to be in the scope of the education policy in Ukraine. In the same time, the international good practices can be used by the Ukrainian pedagogues to improve and to deep the knowledge in the sphere of STEM education. Thus, we have to point the attention on the Massive Open Online Courses (MOOCs) that have being actively introduced in 2008 (Carey, 2012).

The European Schoolnet Academy proposes a free MOOCs that includes theoretical material in the form of texts and video lectures, webinars, videos of teachers of European countries with stories and lessons to share their professional experience, instructions for the practical use of ICT in the professional activity in the classroom, their communication on social networks through course questions and professional solutions, tests for each module of the course and the end result, such as a lesson plan or other ICT training course.

Participation in these courses and analysis of the tasks and topics during 2017–2019 years gave us the opportunity to highlight the following important problems regarding the modernization of the educational process by the teacher according to inquiry-based pedagogy:

- to provide career information to motivate pupils and present a variety of STEAM and ICT-related jobs and required skills ("Teaching ICT with Inquiry"; "The Networked Teacher – Teaching in the 21st Century"; "Games in Schools"; "Personalised Learning in Practice – are my students driving their own learning?"; "Yes I can" – Empowering Student Learning"; "TeachUP Course: Collaborative Learning in Practice – are my students learning through collaboration?");
- to become familiar with innovative tools and approaches such as visual programming tools, unplugged activities, robotics, tinkering, and making and coding for all subjects Ukrainian teachers can join to: "EU Code Week - Deep Dive MOOC"; "The Networked Teacher – Teaching in the 21st Century"; "Games in Schools"; "Yes I can" – Empowering Student Learning"; "TeachUP Course: Collaborative Learning in Practice – are my students learning through collaboration?"; "Boosting Bioeconomy Knowledge in Schools"; "Social Media Literacy for Change";
- to learn about active learning, innovative use of ICT and collaborative teaching and learning teachers can join to: "Teaching ICT with Inquiry"; "EU Code Week - Deep Dive MOOC "; "The Networked Teacher – Teaching in the 21st Century"; "Games in Schools"; "Yes I can" – Empowering Student Learning"; "TeachUP Course: Collaborative Learning in Practice – are my students learning through collaboration?"; "Boosting Bioeconomy Knowledge in Schools"; "Social Media Literacy for Change"; "Become the Next eSafety Champion".

These courses provide suggestions on how to improve the effectiveness of teaching process in the schools, give advice on how to the use the thematic portals and sites, training programs, computer games, etc.

For example, "The Teaching ICT with Inquiry" course allows to use the Go-Lab ecosystem https://www.golabz.eu/ to enhance:

- students to conduct experiments in on-line laboratories in STEM fields, to participate in educational projects, in the implementation of which they need to use knowledge, skills and competences in the natural sciences, technologies, engineering, various fields of arts and mathematics;
- teachers to create and select didactic materials for teaching their subjects using the STEM approach, to share their pedagogical experience with colleagues from different countries of the world, etc.

Go-Lab ecosystem was launched since 2014. The Go-Lab initiative was created thanks to the successful Go-Lab project, which lasted from November 2012 to October 2016. The goal of the Go-Lab Initiative is to promote the use of online labs and applications for teaching and implementing research projects in schools. The Go-Lab Initiative provides a Go-Lab ecosystem for teachers where they can find various online labs and create their own learning spaces. The Go-Lab Initiative provides training for teachers across Europe on science education in schools and the explains how to use of the Go-Lab ecosystem. The Go-Lab initiative is currently funded by the Next-Lab project. The modern Go-Lab ecosystem consists of two main components. Go-Lab is a Sharing platform that provides hundreds of remote and virtual labs, as well as software and applications for query study. The Go-Lab platform enables teachers to create their own learning environments, combining labs, applications, and other resources for sharing with their pupils.

What is important about MOOCs, is that the final result of each of these courses should be a personal training event developed by the course participant, such as a training project using the tools offered by the online course. This result is evaluated using the peer-to-peer method.

It should be noted that the content of the courses is renewed every year, namely:

- new topics (eg, the use of computer games to teach and teach different disciplines, training according to the needs of society, the use of new tools for monitoring, control and self-assessment of knowledge, skills and abilities of students and teachers);
- new tools for improve forms of learning (eg, the use of new electronic platforms for STEAM

projects in formal, non-formal, informal and inclusive learning; creation of computer-oriented environments, etc.);

- new lessons learned from teachers' experiences in implementing STEAM education in the schools (eg, teaching STEAM projects, lessons on specific topics in STEAM fields, STEAM weeks, etc. using ICT);
- updated country reports on the use of ICT in support of STEAM education and analysis of the results of implementation of the STEAM approach in the schools (eg, Science education now: a renewed pedagogy for the future of Europe: https://ec.europa.eu/research/science-society/documentlibrary/pdf06/report-rocard-on-science-educationen.pdf
- new ideas are being generated to implement the STEAM approach in general education institutions (eg, to create websites that offer weeks of STEAM education in schools around the world: https://www.science-on-stage.eu/page/display/5/28/13343/coding-in-stem-education.

The entrepreneurial education is one of the important issue of the sustainable development and democratisation of education process. The vital importance of the development of entrepreneurial competence is defined in the main basic educational documents of Ukraine. The Law "On Education" proclaims entrepreneurial competence and financial literacy as the key competencies for modern citizens (Verkhovna Rada of Ukraine, 2017).

In 2016 the government of Ukraine approved the Concept for the implementation of state policy in the field of reforming general secondary education "New Ukrainian School" until 2029, which states that one of the areas of education reform is to create a modern educational environment that will provide the necessary conditions, tools and technologies for teaching pupils, teachers and parents. According to this reform, a graduate of a new Ukrainian school must be an innovator, able to change the world around him and develop the economy on the principles of sustainable development, compete in the labor market, learn throughout life. Among the key competencies are the information and digital competencies, entrepreneurship and financial literacy, leading a healthy lifestyle (Elkin et al., 2017).

In September 2020, the State Standard for Basic Secondary Education was adopted, which includes key competencies (entrepreneurship and financial literacy), which include initiative, the ability to use opportunities and implement ideas, and create value for others in all spheres of life; ability to actively participate in society, manage their own lives and careers; ability to solve problems; willingness to take responsibility for decision making processes; ability to work in a team to plan and implement projects that have cultural, social or financial value, etc.(Cabinet of ministries of Ukraine, 2020).

The work of Ukrainian scientists is devoted to the problem of formation of entrepreneurial competence of students as a key competence. Thus, Hilberg (Hilberg, 2020) believes that entrepreneurship is a person's ability to implement ideas, which involves creativity, the desire for innovation and the ability to take risks, as well as the ability to plan activities and implement them in life. Liskovych (Liskovych, 2016) defines the entrepreneurial competence of the pupil as a structured set of personal qualities that provide effective problem solutions in various spheres of life related to their own social status and well-being, as well as the development of society and the state as a whole. According to Ovcharuk (Ovcharuk, 2017), one of the main characteristics of entrepreneurial competence is transverse, cross-cutting nature and flexibility. The researcher also considers it extremely importance in using and implementation of active methods and ICT in the educational process, to involve representatives of the local community and business, entrepreneurs who have experience and are ready to share it with pupils (Ovcharuk, 2017). In the study of entrepreneurship education Nazarenko (Nazarenko, 2014) proposes to use game technologies that will allow students to try the role of experts in a given situation or the role of an entrepreneur, whose functions include: planning economic activities, creating a business plan, planning marketing and advertising, funds analysis at the firm and running business. Dovgan and Chasnikova (Dovgan and Chasnikova, 2017) deal with the issues of integration of entrepreneurial competence into secondary education curricula. The researches noted that the introduction of a cross-cutting content line "entrepreneurship and financial literacy" is facilitated by such factors as: the use of interactive teaching methods (simulation of life situation in lessons), excursions (bank, enterprise, firm, etc.), project activities (application of knowledge in practice), teamwork, the ability to present pupils' works, analyze information and draw conclusions, etc.), appeal to the experience of pupils (Dovgan and Chasnikova, 2017).

To identify key competencies in the curriculum, the concept of "cross-cutting lines" was introduced. The cross-cutting line "Entrepreneurship and Financial Literacy" aims to educate young people: rationally use funds, plan expenses, save, and implement leadership initiatives, to operate successfully in a technologically fast-changing environment. Programs of the Ministry of Education and Science of Ukraine of this content line for grades 5–9 have been developed. This information is presented on the website of the Institute for Modernization of Educational Content (The Entrepreneurial School, 2013).

One of the first educational initiatives on the implementation of entrepreneurship education in Ukraine was the Polish Foreign Assistance Program of the Ministry of Foreign Affairs of the Republic of Poland, the Polish-Ukrainian project "School Academy of Entrepreneurship 3". This project was implemented at the all-Ukrainian level and was aimed at the support of the socio-economic sustainable development of the country introduction of elements of entrepreneurial education in schools. This project is a continuation of the Ukrainian-Polish projects "School Academy of Entrepreneurship" (2012–2013) and "Lessons with an entrepreneurial background" (2014). All information and developments of these projects are freely available on the project website (School Academy of Entrepreneurship, 2014). In particular on the website teachers can find a online guidelines for the organization of integrated lessons with "entrepreneurial background" and sample summaries of such lessons.

The use of ICT in the learning process provides an opportunity to create an effective computer-based learning environment (Vlasenko et al., 2020). In Ukraine, there are online resources and online courses that offer education for pupils and teachers on entrepreneurship. Thus, for students of grades 9–11, teachers of Kharkiv Polytechnic Institute together with the platform "For a lesson" developed a free online course "StartUpCamp: the path to a dream" (naurok.ua, 2021). With this course, pupils learn the basics of entrepreneurship, they can get the tools for creation of their own project, and start to implement their business ideas, as well as to learn the basics of financial literacy, work in a team to start their own business project. The course consists of 7 sessions and 300 tasks. Learning takes place in the form of online video lessons with the supervision of a teacher. All lessons can be recorded; there is a gamification of the learning process, the pupils can perform interactively and can deliver presentations on their homework. Also there are a lot of interesting materials for different topics: Philosophy of entrepreneurship; Team game; Business pack leaders; We learn to present our idea; Include critical thinking!; Where to get money? and others.

Another useful digital resource is the National Online Digital Literacy Platform "Action. Digital Education" (Diia, 2021). This platform proposes the educational series "Entrepreneurship for schoolchildren" which consists of 6 modules, and 36 sessions. The first module is devoted to the idea on the topic of "finding ideas", their samples, testing and implementation. The series aims to make pupils aware of the benefits of doing business and forming the traits and positions needed by each person for successful self-realization in today's world. In the process of learning they understand how to find the business idea and test it, promote their own product on the market (from advertising to finding customers), learn about what sources of funding exist and how to attract them. Upon completion of the online course the pupils pass the test.

The Ukrainian online education platform Educational Era is a project that aims to make education in Ukraine at a high quality, accessible and available in a global educational context (EdEra, 2020). This platform offers an online courses for high school teachers, secondary and primary school teachers, social educators, school psychologists, youth workers and parents. The online course "With students about education and career" consists of 4 modules, includes videos, interactive tests, lesson plans. Upon its completion, a certificate (8 hours) is issued. During the training, such issues as educational and career counselling are considered, different tools are available for this; as well as the opportunities for future vocational and higher education in Ukraine and abroad, as well as for nonformal education. Participants are offered tools for working with pupils in grades 8–11: lesson plans, additional materials, presentations, and interactive consultation scenarios. Topics of the modules include: advising pupils on self-knowledge, career and educational trajectory; advising on the choice of vocational education; advising on the choice of higher education; advising on non-formal educational opportunities. To obtain a certificate, participants are tested in each of the modules (middle and end), the final online test is based on the results of the presented materials.

The Educational hub of Kyiv is also one of the useful learning resources (eduhub.in.ua, 2019), that offers its users different courses aimed at the development of soft skills, lifelong learning through blended learning, and serves as a platform for participants' meetings with the famous Ukrainians. Thus, for senior pupils there are the special courses; "Public Speaking", "Career Guidance for Students" and "Effective Job Search" are offered (eduhub.in.ua, 2019). The course "Public Speaking" is aimed at the mastering the skills of speaking convincingly, clearly, and competently, as well as to interest the audience and hold its attention. The basic public speaking course for beginner speakers consists of 7 video lessons:

about the qualities that the speaker should have, what goal he/she can set for himself, what information he/she should have depending on the type of speech; how to learn to control yourself and overcome the fear of public speaking; why for the speaker body language – gestures and facial expressions – is no less important than a well-placed voice; what are the details of the speaker's image, what are the types and archetypes of speakers; what is the real art of public speaking, what role does improvisation, acting skills, language culture play in it; how to build the structure of the speech and what techniques will help to visualize the information to better convey it to the audience; how to conduct a dialogue and discussion with the audience.

The material of each course consists of theoretical information, tests for understanding certain subtleties of public speeches, illustrative examples of successful and unsuccessful speeches. Subsequent classes include questions on the material of the previous ones, and the participant can move forward only after its successful mastering and proper passing of the online test. The course "Career Guidance for Students" is designed to facilitate the choice of profession by high school pupils before entering higher education. The course raises the awareness of the pupils about the benefits of the subjects they study in school and how they will be needed later in their life, namely: civic education, mathematics, language, literature, physics, chemistry, biology and ecology, history, geography, physical education and computer science. The course "Effective job search" teaches modern methods of job search, the rules of writing a good resume, how to choose the right field of activity, company and interview, how to make a good impression on the first working day and more. There are also other platforms for mass open online courses, such as Google Digital Workshop (LearnDigital, 2021), which offer entrepreneurship courses that differ by the number of modules and their duration. A part of the above mentioned courses are for beginners, others are useful even for experienced participants. After hearing some courses it is necessary to pass testing for consolidation of the received knowledge.

From the above mentioned we can conclude that in Ukraine there are opportunities for entrepreneurship education, but there is a lack of the opportunities to create an effective learning environment in school regarding this issue. It remains an important question that needs further development.

Thus, it is necessary to create the most favorable conditions based on the use of ICT to enhance the cognitive activity of children, the development of their intellectual abilities and communication skills necessary for the successful formation of entrepreneurial competence; to create conditions for training teachers in teaching entrepreneurship, providing them with ICT tools and teaching materials, teach them to use existing resources for learning; to develop educational online resources (textbooks, computer programs, games, virtual communities, portals) on entrepreneurship education to support teachers, students and parents; encourage teachers and students to participate in international projects on entrepreneurship education. The use of the achievements and informational resources by Ukrainian teachers allows creating additional opportunities to pupils in the international perspective. This is why the experience of using digital technology by teachers to gain knowledge in business education is interesting. This confirms the creation of European entrepreneurship education resources, such as the Virtual Entrepreneurship Education Handbook, which allows teachers from different countries to familiarize themselves with and use practical tools for primary, secondary and vocational education in their work.

Teachers from European countries are now successfully using the digital teaching hub (http://content.ee-hub.eu/). It brings together over 60 best practices in promoting entrepreneurship education in Europe on: national entrepreneurship education policy (Germany, Italy, Netherlands, Flanders, Denmark, Estonia, Croatia, Sweden, Finland, Macedonia, Norway, Denmark); teacher training (Enterprising School Program, Entrepreneurship360, Entrepreneurship Educators Program 3EP, 100 Mirrors, LIFE2 Project, STEP Model 2); partnerships (Cisco Networking Academy Networking, Combining Entrepreneurial Competence and STEM Industry Partnerships Skills, Accelerating the StartUp Ecosystem, YES – Finnish Regional Ecosystem Strategies to Implement National Strategies, Employee Volunteering – Added Value of Practical Entrepreneurial Programs, etc.); Entrepreneurship education ecosystem (integrates educational institutions of Spain, Serbia, Belgium, United Kingdom, Norway, Germany, Finland); tools (Measurement Tool for Enterprise Education (MTEE), Entre Intention Tool: Measuring Impact at the Individual Level Entre Intention Tool: Measuring Impact at Individual Level, EntreComp: Entrepreneurial Competence Framework, etc.); Financial Education (Interaction between Entrepreneurship and Financial Education, Financial Education Programs from Primary to Secondary Levels, MoneyIQ and MoneyOnline, Financial Education Curricula, Your Finances, Your Future; I Can Manage My Money) and others.

In order to effectively integrate entrepreneurship education into the school education process, modern digital tools are being used to help creation of resources and projects involving representatives from different countries. This digital resource is the Entrepreneurial School (http://theentrepreneurialschool.eu/) that is co-financed by the European Commission, which includes 5 key objectives: teachers' continuing professional development and training; establishing quality supporting frameworks to measure best practice and to evaluate impact; development of appropriate support structures and activities; establishing networks between best practices; focusing on the initial education of teachers and the integration in the curriculum etc. The Entrepreneurial School project has trained over 4,000 teachers from 18 countries over the past three years, and has developed a Virtual Guide to Entrepreneurial Learning (http://www.tesguide.eu/default.aspx) (The Entrepreneurial School, 2013). Focus groups from Denmark, Finland, Italy, Norway, Poland, Portugal, Slovakia and the United Kingdom worked on this development. The focus groups consists of representatives of various education, business, governmental and non-governmental institutions who are relevant to entrepreneurship education in their countries and play a key role in promoting entrepreneurship education.

4 CONCLUSIONS

The use of the digital educational resources in the classroom activities with pupils is one of the vital issues nowadays. The online instruments and digital resources for the realisation of STEM-education, Education for Democratic Citizenship, and Entrepreneurship Education are not widely presented in the national educational practice today. The above mentioned spheres are the modern trends in the world's educational systems. Ukraine started to adapt the educational standards and meet the requirements of the democratic multicultural society. The Ukrainian online resources presented in the article ensure the creation of the sustainable, multicultural, and democratic environment for teachers and students including key competencies areas: entrepreneurship, citizenship, civic education and STEM.

Moreover the creation of the appropriate educational environment that allows pupils to gain knowledge, skills and competencies for their participation into the democratic society is one of the important tasks for the educational system in Ukraine. It is also important to use the best experience and educational resources on democratic education, entrepreneurial education and multicultural communication of other countries. Ukrainian pedagogues should pay attention to the following aspects:

- to integrate entrepreneurship education into the school education process. The use of the modern digital educational resources can help teachers to create opportunities for pupils, promote the involvement of pupils to create their own projects and find opportunities;
- to create possibilities for pupils to develop their democratic culture through participation into the decision making process using ICTs. This will allow promoting the development of digital citizenship that is now one of the life realities.

In this view it should be concluded that the use of digital tools, digital resources and media in the classroom is closely linked to the digital competence. This is why the relevant level of the digital competence has to be one of the main targets of the teaching process.

Further research should be carried out in developing approaches, organizational and pedagogical conditions in schools in order to create the learning environment for the sustainable development that can promote to develop digital competence and digital citizenship enhance entrepreneurship education of pupils.

Also, it is important to develop approaches and create the organizational and pedagogical conditions for pupils and teacher to develop their digital competence and digital citizenship, improving the methods and forms of using digital learning tools to create a democratic and sustainable environment in schools.

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Methodology for using Cloud-oriented Environment for Flipped Learning of the Future IT Specialists

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Abstract: The article substantiates the components of a cloud-oriented environment for flipped learning in the process of training future information technology specialists in higher education institutions. The methodology for using services and resources of the cloud-oriented environment of the university, including mass open online courses, educational portal of the university, professional-oriented software and services for project management for flipped learning in the process of training future professionals is presented in three stages: preparatory, basic and integrated. In these stages, the necessary professional and personal skills were formed during the project tasks performing using the appropriate cloud resources and services of the university environment. At the preparatory stage, students worked on collective projects within one discipline using the cloud service Microsoft Teams in order to form and develop general competencies. At the basic stage, students were offered to perform tasks of mini-projects, group and individual projects during studying professionally-oriented disciplines using the GitHub cloud service. The integrated stage was implemented during work on interdisciplinary projects, the tasks for which were formed on the basis of the study of several disciplines using the Jira service. This paper investigates the effectiveness of the application of the developed methodology for flipped learning using the components of the university's cloud-oriented environment.

1 INTRODUCTION

Sustainable development depends on innovation and the introduction of ICT in various sectors of the economy and livelihoods (Lobanova et al., 2020). That is why providing inclusive and equitable quality education, promoting lifelong learning for all, is one of the global goals of sustainable development. The issue of training quality IT professionals is especially relevant in the context of achieving sustainable development goals, as modern innovation is based on the widespread use of IT. Higher education institutions are constantly confronted with the educational and technological challenges involved in preparing future IT specialists. Teachers are faced with the task of finding new approaches to solving the problem of improving the quality of the educational process, developing students' professional and personal skills. Moreover, employers' expectations of professional qualification requirements must be met. In addition to professional competencies, teamwork, problem-solving and communication skills, so-called soft skills, should be addressed in the future IT specialists (Semerikov et al., 2020; Varava et al., 2021).

We are looking at flipped learning as a way of creating a learning ecosystem, we realise how effective it is. Flipped classrooms connect people and provide them with a variety of content and technology. This increases the engagement of the learners as there is activity-based, practical learning in classroom time. Flipped learning also boosts healthy interaction between members, in a mutually beneficial manner, which is the essential function of an ecosystem. Blended learning (Bondarenko et al., 2018; Polhun et al., 2021; Kucher et al., 2022; Bukreiev

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et al., 2022), interaction between members and informal learning are other characteristics of a flipped classroom that take you closer to developing a learning ecosystem.

Case studies are emerging, in ever greater numbers, which document measurable improvements in student and teacher motivation, increased attendance in class, and better grades, as a result of using the flipped approach (Hamdan et al., 2013; Bishop and Verleger, 2013; Davies et al., 2013).

Innovative approaches in higher education are shifting away from teacher centered instruction to student-centered learning (Béres and Kis, 2018).

The purpose of this article is to substantiate the components of the cloud-oriented environment and methods of its use for flipped learning in the process of training future specialists in information technology, and to study the effectiveness of the developed methodology for project learning.

2 THEORETICAL BACKGROUND

The number of alternative teaching methods being explored in Computer Science (CS) education is increasing in an attempt to address both pedagogical and financial challenges, such as creating active learning experiences with increasing financial pressures (Kaner and Fiedler, 2005; Semerikov et al., 2021).

There are two common characteristics which encapsulate a flipped classroom:

1) an easily adaptable learning environment that facilitates active learning and allows students to develop different skills and competencies (DeLozier and Rhodes, 2017; Smyrnova-Trybulska et al., 2017; McLaughlin et al., 2013; Little, 2015);
2) a student-centred learning culture (Bishop and Verleger, 2013; de Bruin et al., 2014).

According to the Flipped Learning Network the flipped classroom approach has four pillars (Flipped Learning Network (FLN), 2014). In order for teachers to achieve this approach, they have to take these four elements into consideration:

- Flipped learning requires flexible environments
- Flipped learning requires a shift in learning culture
- Flipped learning requires intentional content
- Flipped learning requires professional educators.

The concept of flipped learning is to provide to student's lectures in a video format and other supportive materials to review as their homework, get the maximum of it, and then, use the next class time for in-class activities and problem-solving exercises. The flipped classroom serves as a platform to achieve a collaborative and organic learning environment. To meet the challenges and complexities of the 21st century workplace environment, there has been a shift and adoption of an organic learning environment in the business community. Similarly, universities and accreditation bodies in business schools are moving towards developing competency-based curricula where learners foster lifelong learning skills through a process of self-directed learning (Rajaram, 2019).

Maher et al. (Maher et al., 2015) presented experiences in developing flipped courses: the temporal structure, alternative sources for video instruction and strategies for active learning. Video instruction precedes skills development and concept learning, in-class lab activities scaffold for open ended homework projects and promote peer learning, and in-class quizzes lead to discovery of misconceptions.

The article (Silva et al., 2018) is aimed at analyzing the effects of learning analytics on engineering students' self-regulated learning in a flipped classroom. Results demonstrate that learning analytics can be used to promote self-regulated learning in flipped classrooms, helping students identify strategies that can increase their academic performance. Flipped learning approaches have students use technology to access the lecture and other instructional resources outside the classroom in order to engage them in active learning during in-class time (Nam and Giang, 2017).

Scenarios and collaboration tools for students' practical activity, provides examples of learning objects representing resources for independent study and research, and criteria for assessing the effectiveness of the proposed model of flipped learning are described by Smyrnova-Trybulska et al. (Smyrnova-Trybulska et al., 2017).

The active learning techniques integrate the student centered learning methods such as cooperative learning, problem-based learning, project based learning and peer assisted learning. These learning approaches mean that students work in groups in order to develop and reach their learning goals (Béres and Kis, 2018).

One of the aims of the flipped learning technology is the transition of the educational process organization from passive student learning to the active one, in which future specialists participate in collaborative work, carry out team projects, discuss and solve practical problems in the classroom, applying the theoretical knowledge they have acquired prior to the classroom lessons. By providing students with basic theoretical knowledge prior to the class, the teacher becomes a facilitator, thus enabling students to deepen their knowledge and practical skills during the class and independently manage their own educational process.

The scheme of the educational process organization under the flipped learning technology of future specialists in information technologies is presented in figure 1.

Prior to the classes, students need to acquire basic theoretical knowledge in each academic subject using the resources of the e-learning course (ELC), further deepen the acquired knowledge independently by studying the various MOOCs recommended by teachers. During the classes, students plan joint activities, work on the project as a team, performing practice-based tasks. In the classroom, students consult the teacher on the problematic issues. After classes, the student teams performed tasks assigned to each participant within the project and addressed controversial issues if they arouse among the team members regarding the project tasks.

The use of modern information technologies further enriches the flipped learning process and foster the skills needed by future IT specialists. At the World Economic Forum in 2019, it was determined that it is important to pay attention to the ways and forms of the educational process organization, out of which they single out the study of information technologies with an emphasis on teamwork and creativity, learning through games that develop critical thinking, support of students' initiative outside the educational programs.

A cloud-based environment for organizing the learning process through the technology of flipped learning should provide e-support for the activities of students and teachers at the stages "before class", "in class", "after class". The essence of the notion and the possibility of using a learning environment are considered in (Bondarenko et al., 2020; Kolgatin et al., 2022; Korotun et al., 2020; Lavrentieva et al., 2021; Merzlykin et al., 2017; Nosenko et al., 2016; Pererva et al., 2020; Saad and Rana, 2014; Salam and Sardar, 2015; Shyshkina, 2016, 2018; Shyshkina and Popel, 2013; Vlasenko et al., 2020; Zelinska et al., 2018).

Cloud environment for the study of the "Computer Networks" academic discipline are described in article (Spirin et al., 2019), which was deployed at the Faculty of Physics and Mathematics of Ternopil Volodymyr Hnatyuk National Pedagogical University and investigate the effectiveness of blended learning in such an environment.

Supported by the information and communication technologies, teachers have many options for improving the effectiveness of teaching, in particular the organization of teamwork projects in the process of training future IT specialists.

The cloud-oriented environment was designed at the National University of Life and Environmental Sciences (NULES) of Ukraine for training the future IT specialists under the flipped learning technology (figure 2). Selection criteria for cloud services and resources that will be appropriate in the process of training future IT professionals are analysed in (Korolchuk, 2019). The university's cloud-oriented environment provides students, who major in IT with a variety of types of resources and services that make it possible to use:

- prior to classes within the framework of independent work with e-resources: e-learning courses (ELC) in accordance with the curriculum for training specialists using the Moodle LMS; Khan Academy; online courses from Microsoft and Cisco leading technology companies, respectively, Microsoft Imagine Academy, Cisco Networking Academy; Massive Open Online courses (MOOC), such as Coursera, Udemy, Prometheus, edX, Khan Academy and others;
- in the classroom: professionally-oriented software and cloud services, namely: Microsoft Office 365; Visual Studio; draw.io; services for collective IT development (GitHub, Bitbucked, DeployBot, Phabricator, BeanStalk); Miro;
- for the cooperation outside the university, services to manage collective projects such as: Microsoft Teams, Jira, Trello, Asana, YouTrack.

The design of a cloud-oriented environment for the implementation of projects enables teachers to choose the means available to complete the project's tasks, integrate the necessary services and resources into the created environment, and provide communication between the educators, who teach the project disciplines and the teams of students; students have the opportunity to effectively plan project implementation steps, distribute tasks among team members and monitor their implementation, organize teamwork to create the end product of the project.

To understand the attitude of students to the cloud-oriented environment of the university, we have defined 3 criteria for evaluating them from the standpoint of functionality of the cloud-oriented environment:

1) to perform professional tasks;
2) to implement the flipped learning technology;
3) to manage project implementation.

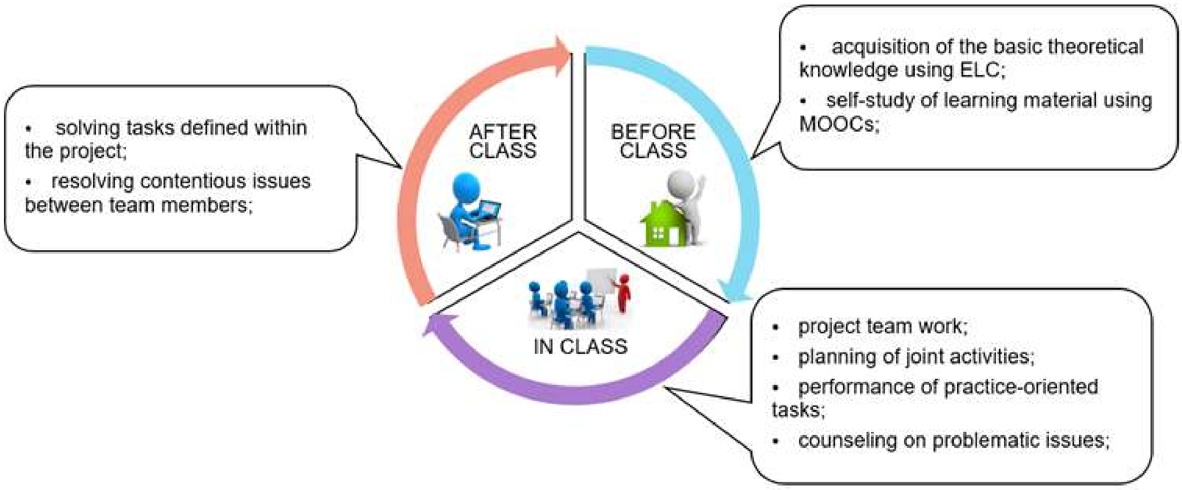

Figure 1: The scheme of the educational process organization under the flipped learning technology.

Indicators under the first criterion include: accessibility (ability to work from any device); reliability (high-quality functioning of the cloud-oriented environment); flexibility (designed and used in line with learning objectives); expediency (need for use to solve problems); convenience (clarity and ease of use); support for processes (communication, collaboration, cooperation, planning and control); teamwork (the ability to organize teamwork, create team projects); integrity (ensuring a continuous educational process); integration with other cloud services; support of various programming technologies; the ability to access open code software.

Indicators under the second criterion are the following: availability of training resources in a cloud-oriented environment; completeness of educational material for students to acquire theoretical knowledge independently; completeness of training material necessary for practical tasks; convenience for independent preparation for the class; convenience of interaction of team members in practical activity; convenience for self-control; convenience for checking the level of acquired knowledge.

Indicators under the third criterion are the following: ease of team work organization; convenience in planning the work on a collaborative project; ease of roles and areas of responsibility allocation for each team member; the convenience of controlling the timing of each task; convenience of communication among the team members; ease of interaction of team members during team development; ease of checking completed tasks; ease of managing software versions.

In the article (Glazunova et al., 2020) the efficiency of the cloud-oriented environment is determined by the three above-mentioned categories and evaluation indicators by interviewing students, before and at the end of the collective project on the technology of flipped learning using cloud-oriented environment.

In evaluating the performance of a cloud-oriented environment, students identified the following most important indicators: support for the process, support of various programming technologies, integration with other cloud services, and accessibility. The concordance coefficient was 0.693, which indicates the average degree of agreement of experts' opinions. Evaluation of the results for determining the performance of a cloud-oriented environment in table 1. The weights of the considered parameters were calculated on the basis of the sums obtained.

When evaluating the performance of a cloud-oriented environment, the teaching staff found out that flexibility, support for the process, teamwork, and integration with other cloud services were the most important indicators. The concordance coefficient was 0.742, which indicates a high level of agreement of experts' opinions. Evaluation of the results of determining the effectiveness of the cloud-oriented environment for the project activity in table 2.

When evaluating the effectiveness of a cloud-oriented environment for the project activity, teachers singled out the following indicators as the most important ones: convenience of organizing teamwork, the ease of interaction of team members in team development, and the ease of planning for a team project. According to the students, the most important indicators are the ease of teamwork organization, the ease of interaction of team members during team development and the ease of managing software (program code) versions. Evaluation of the results of de-

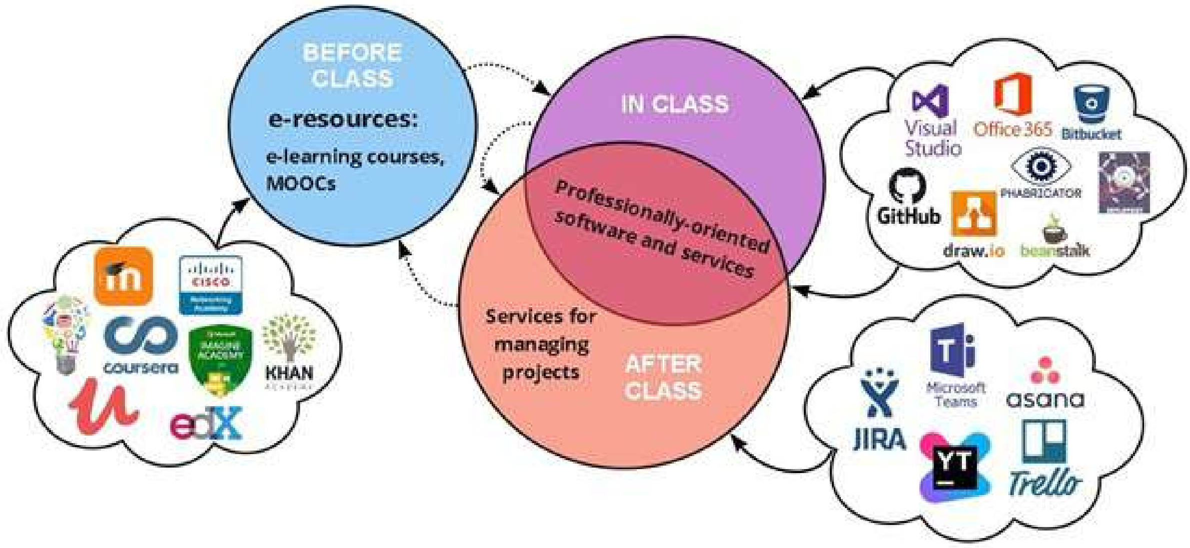

Figure 2: Components of the cloud-oriented environment for flipped learning.

termining the effectiveness of a cloud-oriented environment for flipped learning in table 3.

Evaluating the effectiveness of the cloud-oriented environment for flipped learning, the teachers noted that the convenience of checking the level of acquired knowledge, completeness of educational material for students' independent mastering of theoretical knowledge and completeness of educational material needed to perform practical tasks were the most important indicators.

3 METHOD

The designed cloud-oriented environment of the university is the main component of the flipped learning system for the training of future IT professionals. According to students' opinion, this environment should meet the following requirements: process support (communication, collaboration, cooperation, planning and control), ease of distribution of roles and areas of responsibility of each team member. At the same time, teachers with more weight, compare to students, identified the following indicators of the effectiveness of this environment: the convenience of checking the level of acquired knowledge, flexibility (designed and used according to learning objectives), ease of teamwork, completeness of educational materials for practical tasks. Thus, we used the appropriate environment taking into account the relevant requirements for the development and justification of the methodology, which consists of three stages: basic, preparatory and integrated. During these stages, the necessary professional and personal skills were formed during the performance of project tasks using cloud resources and services of the university environment.

The purpose of the first (preparatory) stage of the methodology for using cloud-based environment for flipped learning of future specialists in information technology is the formation of teamwork skills, communicative and management skills during the performance of collective projects within one discipline with the use of services for project management. The preparatory stage is important for the formation of different students' competences, not only professional competencies in the development of IT projects. The need for independent performance of a part of the project and collaboration contributes to the formation of soft skills, in particular, communication and leadership.

In the preparatory phase, the Microsoft Teams cloud service was used to perform tasks and organize team work, as this service allows you to create an environment for teamwork, set tasks for team members, plan collaboration and integrate additional tools needed to complete project tasks.

In the curriculum for training IT specialists at the first stage, which is the beginning of the methodology, it is necessary to form soft skills that are needed for successful project implementation: teamwork skills, communication and management skills. For this purpose, the discipline "Information Technology" was chosen, during which the project to perform was proposed within the educational practice. During each of the stages of project work within the discipline, stu-

Table 1: Evaluation of the results for determining the performance of a cloud-oriented environment.

Indicators	**Teaching staff Weight**	**Students Weight**
accessibility (ability to work from any device)	0.02	0.11
reliability (high-quality functioning of the cloud-oriented environment)	0.08	0.04
flexibility (designed and used in line with learning objectives)	0.18	0.07
expediency (need for use to solve problems)	0.08	0.03
convenience (clarity and ease of use)	0.08	0.06
support for processes (communication, collaboration, cooperation, planning and control)	0.15	0.17
teamwork (the ability to organize teamwork, create team projects)	0.12	0.09
integrity (ensuring a continuous educational process)	0.11	0.02
integration with other cloud services	0.12	0.13
support of various programming technologies	0.05	0.16
the ability to access open code software	0.01	0.10
Total	1	1
Concordance coefficient	0.742	0.693
Calculated χ^2	59.36	235.62
Table χ^2 (k=10, $\alpha = 0.05$)	18.309	18.309

Table 2: Evaluation of the results for determining the performance of a cloud-oriented environment.

Indicators	**Teaching staff Weight**	**Students Weight**
ease of teamwork organization	0.24	0.23
convenience in planning the work on a collaborative project	0.19	0.12
ease of roles and areas of responsibility allocation for each team member	0.06	0.03
convenience of controlling the timing of each task	0.04	0.09
convenience of communication among the team members	0.01	0.12
ease of interaction of team members during team development	0.22	0.21
ease of checking completed tasks	0.14	0.02
ease of managing software (program code) versions	0.06	0.18
Total	1	1
Concordance coefficient	0.918	0.813
Calculated χ^2	51.48	193.49
Table χ^2 (k=7, $\alpha = 0.05$)	14.068	14.068

dents develop the ability to organize joint activities and form a capable team, the ability to form a communication system in a team, using appropriate cloud services, the ability to take control of the situation, the ability to unite a group and build an effective team interaction to solve certain tasks, etc.

Since the educational practice (technological, project-technological) is carried out after the completion of theoretical training, it is important to form tasks for educational practice on the basis of practice-oriented approach. Thus, educational practice is the stage of students' educational activity, during which the acquired skills in certain disciplines are applied. Educational practice in the university is an important tool for professional self-determination and future professional development.

During the educational practice, special attention is paid to modern methods, forms, tools, instruments and services in the field of their future profession in accordance with the educational degree; formation of knowledge, professional skills and abilities for independent decision-making while working in real market-oriented and production-oriented conditions, education of the need to systematically update their knowledge and creatively apply it in practice. At this stage, the focus should be on the application of problem-based, project-based and practice-oriented methods in student learning. Along with the listed methods, the flipped learning method should be used, as in educational practices students study theoretical

Table 3: Evaluation of the results for determining the performance of a cloud-oriented environment.

Indicators	**Teaching staff Weight**	**Students Weight**
availability of training resources in a cloud-oriented environment	0.11	0.19
completeness of educational material for students to acquire theoretical knowledge independently	0.23	0.04
completeness of training material necessary for practical tasks	0.17	0.25
convenience for independent preparation for the class	0.06	0.13
convenience of interaction of team members in practical activity	0.14	0.10
possibility of self-control	0.02	0.24
convenience for checking	0.27	0.04
Total	1	1
Concordance coefficient	0.728	0.748
Calculated χ^2	34.944	152.592
Table χ^2 (k=6, α = 0.05)	12.593	12.593

material independently outside the classroom, and directly during the classroom practice time they perform practice-oriented tasks. The procedure for using the cloud service MS Teams for flipped learning is shown in the figure 3.

Thus, organizing the collective project using the cloud service MS Teams, students develop professional competencies and soft skills in all components, namely the formation of teamwork skills, communication and management skills during the performing of collective projects by future IT professionals using flipped learning method.

At the basic stage, the GitHub cloud service was used, as this service allows students to use the built-in code editor, work collaboratively on program code, manage code versions and discuss it with other team members. This meets the criteria for the effectiveness of a cloud-based environment, namely: the ability to access open source software, the convenience of managing software versions and the convenience of team members‘ collaboration in practice performance.

The purpose of the second stage is the development of future IT professionals' professional competencies and personal effectiveness as a result of participation in mini-projects, group and individual project tasks, course projects within professional disciplines using services for collective IT development. During the second stage, the proposed method offers collective mono-projects during the study of professional disciplines or course work within such disciplines, which will ensure the formation of future IT professionals‘ professional competencies and soft skills using services for collective IT development for flipped learning, namely: the ability to define the goal and achieve the goal, the ability to properly prioritize tasks within a limited time, to rationally estimate their own time and skills in developing an IT project, etc. At this stage, disciplines for the effective formation of these skills are identified. Such disciplines include "Object-Oriented Programming", "Software Development Technologies", "Cross-Platform Programming", etc.

According to the defined content of such projects, it is necessary to choose forms and methods of teaching that will allow students to form the necessary skills and abilities at this stage. Along with the project method, to study the theoretical material and perform the tasks the method of blended learning should be use, in which part of the material students will learn online, partly independently managing their time and pace of learning and completing tasks. For the organization of projects in combination with the method of flipped learning, it is advisable to use ELC in combination with cloud services for the development of IT projects. Figure 4 shows the procedure for using the GitHub cloud service for flipped learning during the implementation of a mono-project within professionally-oriented disciplines.

Within this process, students develop professional competencies as a result of performing tasks in professionally-oriented disciplines, as well as soft skills, such as: the ability to set goals and achieve goals, the ability to properly prioritize tasks within a limited time, rationally calculate their own time, etc.

At the integrated stage, project management services such as Jira, Trello, Asana were used, as these services allow students to plan collaborative work during performing of interdisciplinary project. At this stage, IT students develop professional competencies, strategic management, personal effectiveness and information management, IT project management skills in the process of participating in interdisciplinary projects using services for project management and collective IT development. Another type of

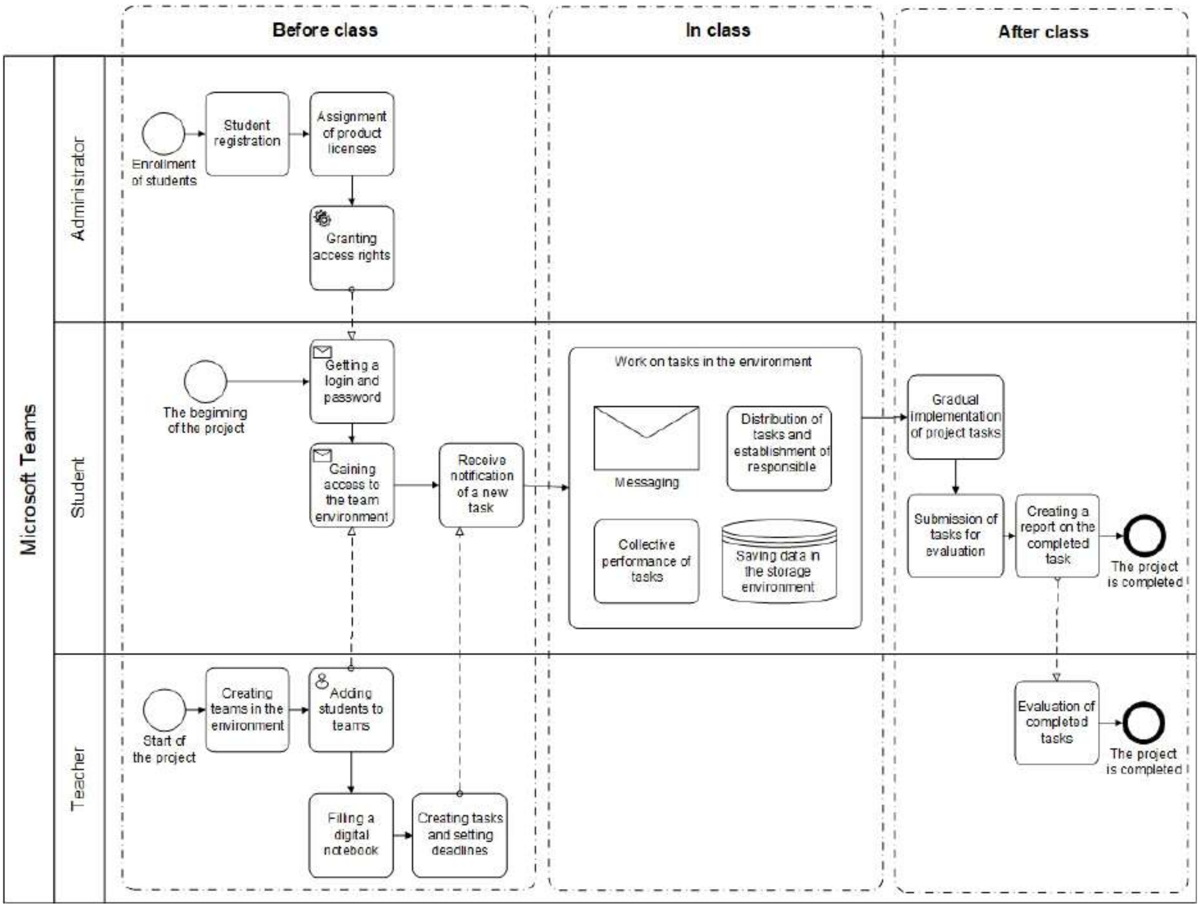

Figure 3: Procedure for using the MS Teams cloud service for flipped learning.

projects that are recommended for implementation at the 3rd stage of the methodology are interdisciplinary projects. At this stage, the content of an interdisciplinary project in three disciplines: "Systems Analysis", "Web Technology and Web Design", "Economics and Business" was determined for the formation of personal effectiveness skills, strategic and information management skills, as well as IT project development and project management skills.

According to the content of the interdisciplinary project defined by the teachers, it is necessary to choose methods and forms of teaching, both traditional and cloud-oriented. Traditional forms and methods of teaching should be used in the study of theoretical material and practical work in the disciplines involved in the project. In particular, the method of flipped learning should be used to develop theoretical material using the resources of the ELC during independent work. During the classroom work it is necessary to organize the work of students in groups on the implementation of practice-oriented tasks that are part of the project. Cloud-oriented teaching methods should be used for communication, joint work on project tasks in a cloud-oriented environment. Thus, it is necessary to combine the project method and the method of flipped learning, when students will study theoretical material and perform practical work independently, and in the classroom will work on solving project problems. The procedure for using the cloud service for inverted learning during the implementation of an interdisciplinary project is developed on the example of the Jira service, which is shown in figure 5.

The use of this process allows forming in future information technology professionals professional competencies in the professional disciplines involved in the project and soft skills, namely: strategic management skills, personal effectiveness, information management and IT project management skills.

The students were offered to implement the cross-disciplinary project on the topic of "Web-oriented system for the IT industry", with the purpose of carrying out systematic analysis, developing a web-oriented system and evaluating the investment attrac-

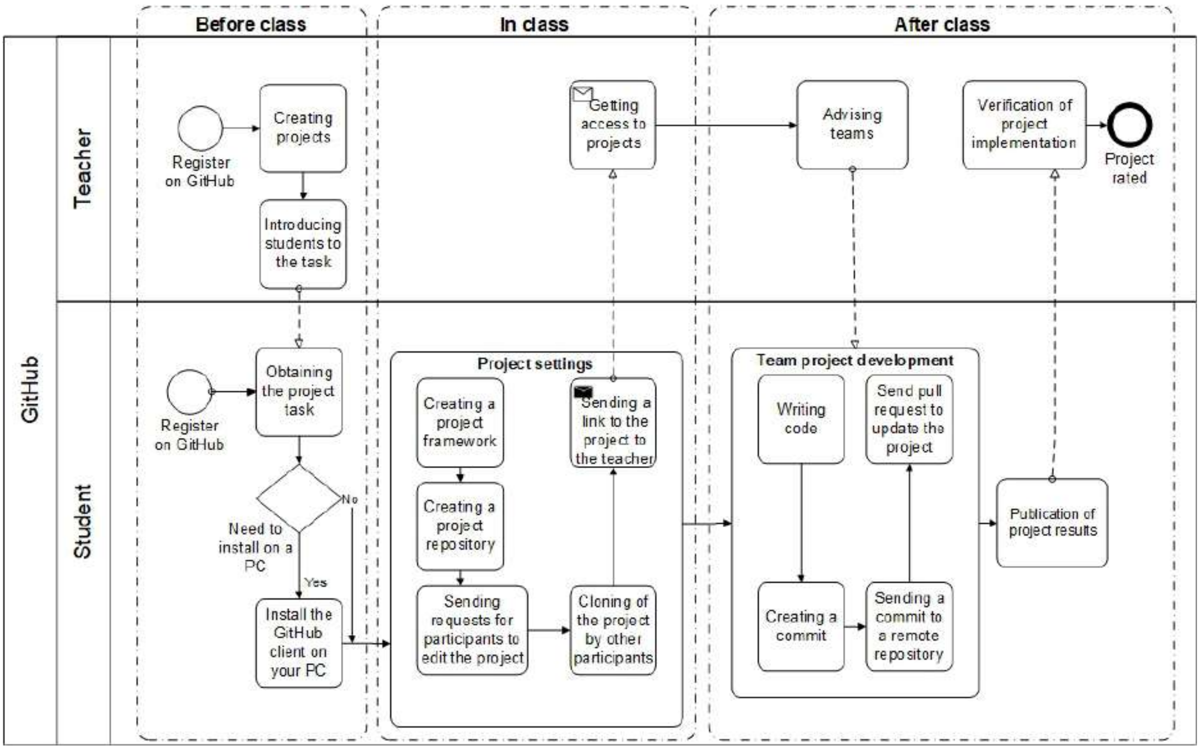

Figure 4: Procedure for using the GitHub cloud service for flipped learning.

tiveness of the developed system. The content of the project was to develop a project for starting their own IT-business, namely: conducting an analysis of the IT services market; carrying out structural, functional and object-oriented analysis of the domain; designing the database and system functionality; developing a web-based system for the IT company; creating a business plan for the company and accordingly calculating the payback of the project as well as strategizing the company's development.

We distinguish the following 8 stages of such a collaborative project implementation under the flipped learning technology: setting a task and processing theoretical material (1); structuring the task and subdividing it into specific tasks (2); role distribution, definition of terms and responsibilities (3); performance of basic tasks (4); joint work of the task team (5); assessment of the quality of the task (6); drawing up a report on the work performed (7); presentation of results (8).

The teamwork was subdivided into 3 parts, according to the tasks of each academic discipline that were part of the cross-disciplinary project. In the course of completing the tasks in the "System Analysis" academic discipline, the students had to conduct an analysis of the IT services market, to choose the profile of the future company, to develop the functionality of the future business, to carry out structural-and-functional and object-oriented analysis, to design information support and to describe the specification of management processes. In the course of "Web Design and Web Technologies" academic disciplines, the students developed the website of the future company and integrated it into the information management system of the company. The tasks in the "Economics and Business" academic discipline required students to analyze the necessary tools to start their own business, to develop a business plan for the future company, to formulate a strategy for its further development, to calculate the basic income and expenditure, as well as to evaluate its economic efficiency and investment attractiveness.

Prior to the commencement of training (before class): instructions were developed for each task of the project beforehand, and necessary training materials were placed in electronic training courses (ELCs) for each academic discipline. The teaching materials at ELCs were designed according to the students' learning styles. Often the same material was offered in different formats according to the research provided in (Morze and Glazunova, 2014). Thus, the students studied basic theoretical materials in the ELC of the corresponding academic disciplines, got acquainted with the project objectives, registered and

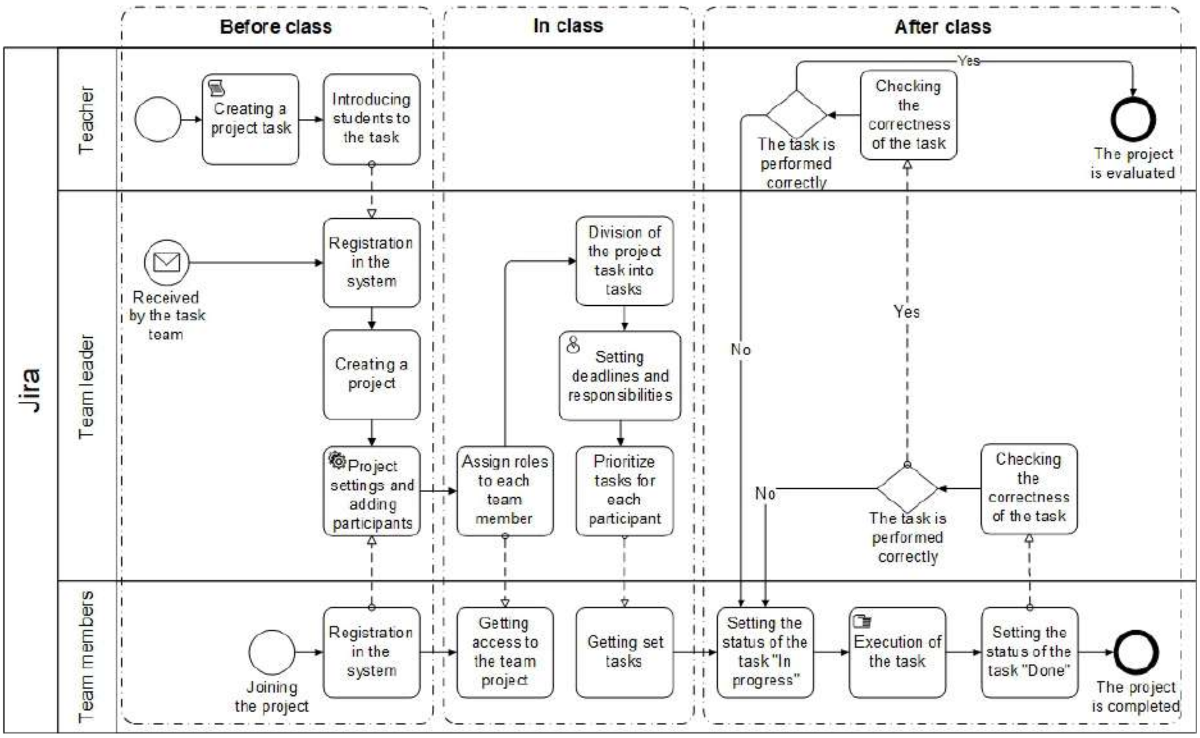

Figure 5: Procedure for using the Jira cloud service for flipped learning.

selected MOOCs for the independent study of the required material in accordance with their learning style. An in-depth study of the theoretical material, required for students to complete the assignments, took place in lectures alternately in each academic discipline as per schedule. The students studied the selected professionally oriented software and project management services offered by the teachers for each stage of the cross-disciplinary project.

In class: all the students were required to participate weekly in interactive lectures and laboratory work. During such classes, students were asked to develop a project based on the tasks of three identified academic disciplines of the cross-disciplinary project. The first session involved getting acquainted with the subject and tasks of the project in detail in each academic discipline. The students were divided into teams of 4 people, then within the team they were assigned roles and areas of responsibility of each team member; further the team members defined the terms of implementation and appointed those responsible for each project task. The task of the students was to understand the problem, to evaluate the complexity of the works, to find options for their solution, to divide the received tasks into separate tasks, to apply the theoretical and practical knowledge acquired before the beginning of classes to solve the project's tasks. In class the students were advised by the teacher on the progress of the course; they acquired basic skills in performing specific tasks via professionally oriented software and services of the university cloud-oriented environment.

After class: team members jointly performed project tasks in each academic discipline, collaborated using project management and IT-team services. In the course of the project, the students evaluated the tasks completed personally as well as those completed by other team members. If necessary, they refined the tasks to the appropriate professional level, created reports in the form of a presentation, which reflected the results of the team at all stages of the project. In the end, each team presented the results of their project, and teachers and participants of other teams evaluated the readiness for the implementation.

Figure 6 shows a diagram of one of the cycles of fulfilling the tasks of a cross-disciplinary project under the flipped learning technology using the cloud-oriented university environment.

Table 4-6 defines in more detail the types of activities in the process of the implementation of each stage of the project, during which the students develop professional, integrated, self-educational competences and soft skills, for each of the above stages of the cross-disciplinary project using a cloud-oriented environment.

Thus, the implementation of such cross-

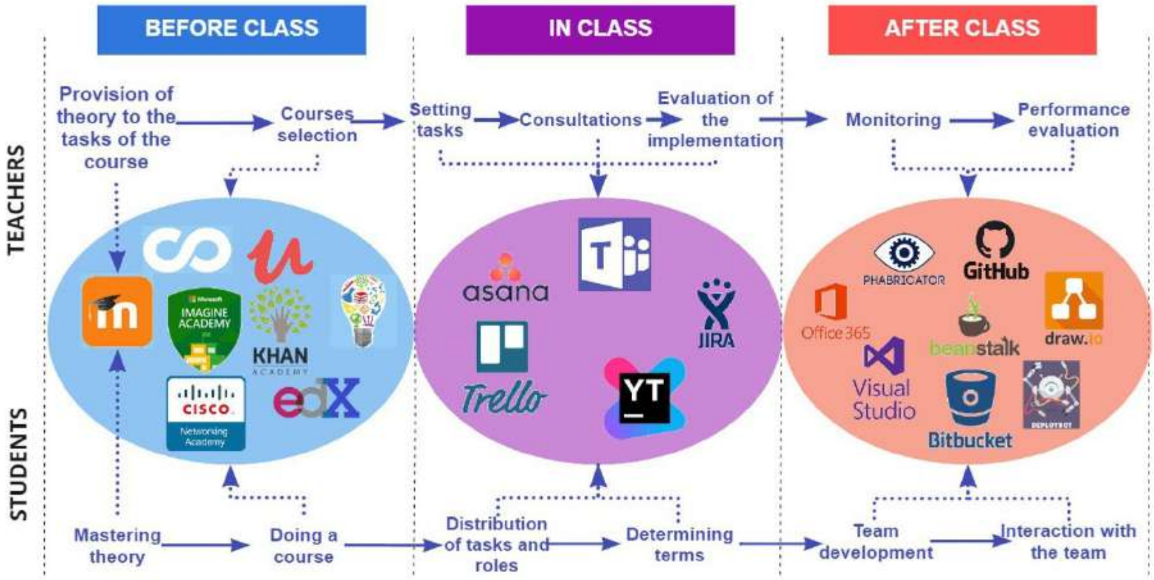

Figure 6: The diagram of one cycle of the cross-disciplinary project under the flipped learning technology using the cloud-oriented university environment.

Table 4: Organization of the cross-disciplinary project under the flipped learning technology using the cloud-oriented environment before class.

Contents of the stage	**Activity**	**Tools**	**Competence**
Setting tasks and mastering of the theoretical material	getting acquainted with the aim and tasks of the project; studying the theoretical material in ELC; registration and selection of MOOC; doing online courses	LMS Moodle; Cisco Academy; Prometheus; Coursera; Microsoft Imagine Academy; Udemy; Khan Academy	self-educational; professional; ability to search, process and analyze information from various sources

disciplinary project tasks involved activities at certain stages, which resulted in the development of professional, integrated, self-educational competences, as well as communication, interpersonal, leadership, teamwork and time management skills, the so-called “soft skills”.

4 RESULTS

The timeframe of the study is 3 years. The pedagogical experiment involved students of the 3rd year of Computer Science and Computer Engineering specialty at the Faculty of Information Technologies of NULES of Ukraine.

Students were divided into two groups: experimental group $N = 115$ (students majoring in Computer Science and control group $N = 109$ (students majoring in Computer Engineering). The control group of students did not have access to the resources and services of the cloud-oriented environment and studied the technology of flipped learning, performing project tasks in accordance with the stages. Students of the experimental group studied according to the methodology of using the components of the cloud-oriented environment for inverted learning in three stages: preparatory, basic and integrated. Levels of student success were assessed at the end of each project according to the proposed methodology. To test the effectiveness of such an environment for inverted learning, a null hypothesis was put forward that the average learning score in the control and experimental groups did not differ. The rejection of this hypothesis will allow us to argue that the use of such a cloud-oriented environment for flipped learning of future IT specialists will increase student academic performance. Student’s t-test was used to test the proposed statistical hypothesis. When applying this criterion for independent samples, two conditions must be met: exceeding the required minimum sample size and equality of variances. To determine the sufficiency of the sample size for the t-criterion with a significance level of 0.05, a power of 80% and a standard

Table 5: Organization of the cross-disciplinary project under the flipped learning technology using the cloud-oriented environment in class.

Contents of the stage	Activity	Tools	Competence
Structuring the material and dividing it into specific tasks	evaluation of the task complexity; search for solutions to the problem; division of the task into separate tasks	Microsoft Teams; Jira; Trello; Asana; YouTrack	ability to work in a team; knowledge and understanding of the subject area; ability to make decisions
Allocating roles, appointing people in charge, setting the date	allocation of roles and areas of responsibility of each team member; appointment of those responsible for each task	Microsoft Teams; Jira; Trello; Asana; YouTrack	ability to work in a team; ability to make decisions
Performing basic tasks	solving practical tasks according to the aim of the task performance consultation with the teacher on problematic issues	GitHub; Bitbucked; DeployBot; Phabricator; BeanStalk; professionally-oriented software and services	professional; integral; the ability to apply knowledge in practical situations

mean effect, an analysis of the value of the selection was conducted, which is presented in figure 7.

```
pwr.t.test(d=0.5, sig.level=0.05, power=0.80)

##      Two-sample t test power calculation
##               n = 63.76561
##               d = 0.5
##       sig.level = 0.05
##           power = 0.8
##     alternative = two.sided
```

Figure 7: Estimation of the sample size.

Estimation shows that at least 64 people are required to apply this method in each of the two samples of students (control and experimental).

To verify the second condition, a test for the equality of variances was performed, which is presented in figure 8.

```
var.test(rating~group,data=Data)

## F test to compare two variances
## data:  rating by group
## F = 1.132, num df = 344, denom df = 326, p-value = 0.258
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.9130388 1.4024852
## sample estimates:
## ratio of variances
##           1.131957
```

Figure 8: Test for equality of variances.

The calculations showed that the probability of obtaining an error of the first kind is 25.8% with a permissible 5%, to reject the null hypothesis. Therefore, the variances are statistically equal, which allows to estimate the averages by the t-test.

The estimation of the t-test for the general averages in the two groups is presented in figure 9.

Descriptive characteristics of samples on grades (academic performances) are shown in table 7.

```
t.test(rating~group,data=Data, var.equal = TRUE)
##  Two Sample t-test
## data:  rating by group
## t = 7.7655, df = 670, p-value = 3.054e-14
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  4.804434 8.056249
## sample estimates:
## mean in group Experimental  mean in group Control
##                  79.90435               73.47401
```

Figure 9: Estimation of the general averages in control and experimental groups on Student's t-test.

Comparing the groups‘ total average, we see a difference of 6.4 points on the overall score. The biggest difference was at the 3rd stage – 8.

Analyzing, we see the difference in the medians, as well as the distribution of scores – the experimental group shows the better results for both the general result and results by stages (figure 10).

According to the results, the Student t-test calculated according to experimental data exceeds the critical value of $-7.77 > 1.967$ for a given level of significance (0.05), which is necessary for reject the null hypothesis of equality of the two means. Therefore, we can conclude that the difference between the average grades between the control and experimental groups (6.4 points) is statistically significant. In this case, with a probability of 95%, this difference will be from 4.8 to 8.1 points. Accordingly, based on the results of analysis of variance, we can say that the method of using a cloud-based environment for inverted learning of IT students affects their academic achievements.

5 CONCLUSIONS

In the study which lasted for 3 years a cloud-based environment was used to implement flipped learning

Table 6: Organization of the cross-disciplinary project under the flipped learning technology using the cloud-oriented environment after class.

Contents of the stage	Activity	Tools	Competence
Tem work on task completion	step-by-step implementation of project tasks in each academic discipline (domain analysis, site development, project cost-performance calculation)	GitHub; Bitbucked; DeployBot; Phabricator; BeanStalk; professionally-oriented software and services	professional; integral; the ability to apply knowledge in practical situations
Evaluation of the quality of the task performed	evaluation of independently completed tasks; evaluation of tasks performed by other team members; refinement of tasks	GitHub; Bitbucked; DeployBot; Phabricator; BeanStalk; professionally-oriented software and services	ability to be critical and self-critical; the ability to evaluate and ensure the quality of work performed
Report generating on the work performed	generating a team work report on the project	Power Point Online; Sway	the ability to visualize, formulate, solve problematic situations, making the right decisions, taking into account available information
Presentation of results	report placement; evaluation	Miro	the ability to present the project to investors or your own team

Table 7: Descriptive characteristics of samples on grades.

Stage	Group		Total average	Difference
	Experimental	Control		
Stage 1	81.3	74.6	78.1	6.7
Stage 2	78.2	73.6	76	4.6
Stage 3	80.2	72.2	76.3	8
Total average	79.9	73.5	76.8	6.4

projects in the education process of future IT specialists. The developed methodology is based on the use of services for project management and collective IT development during three activity stages: preparatory, basic and integral.

One of the most important results obtained during the study was the identification of performance indicators for the developed cloud-based environment model, which cover the functionality of the environment by 3 criteria, namely: for the professional activity, for the implementation of the flipped learning technology and for the project management. The cloud-oriented environment of the university designed on the basis of determined coteries and indicators is the main component of the flipped learning system for the training of future IT professionals. The design of this cloud-oriented environment for the implementation of projects enables teachers to choose the means available to complete the project's tasks, integrate the necessary services and resources into the created environment, and provide communication between the educators, who teach the project disciplines and the teams of students; students have the opportunity to effectively plan project implementation steps, distribute tasks among team members and monitor their implementation, organize teamwork to create the end product of the project.

Procedures for using Microsoft Teams, GitHub, Jira cloud services are developed on the basis of process models, make it possible to regulate these processes and provide the effective use of the methodology at three stages.

In these stages, the necessary professional and personal skills were formed during the project tasks performing using the appropriate cloud resources and services of the university environment. During each of the stages students develop the ability to organize joint activities and form a capable team, the ability to form a communication system in a team, using appropriate cloud services, the ability to take control of the situation, the ability to unite a group and build an effective team interaction to solve certain tasks, etc.

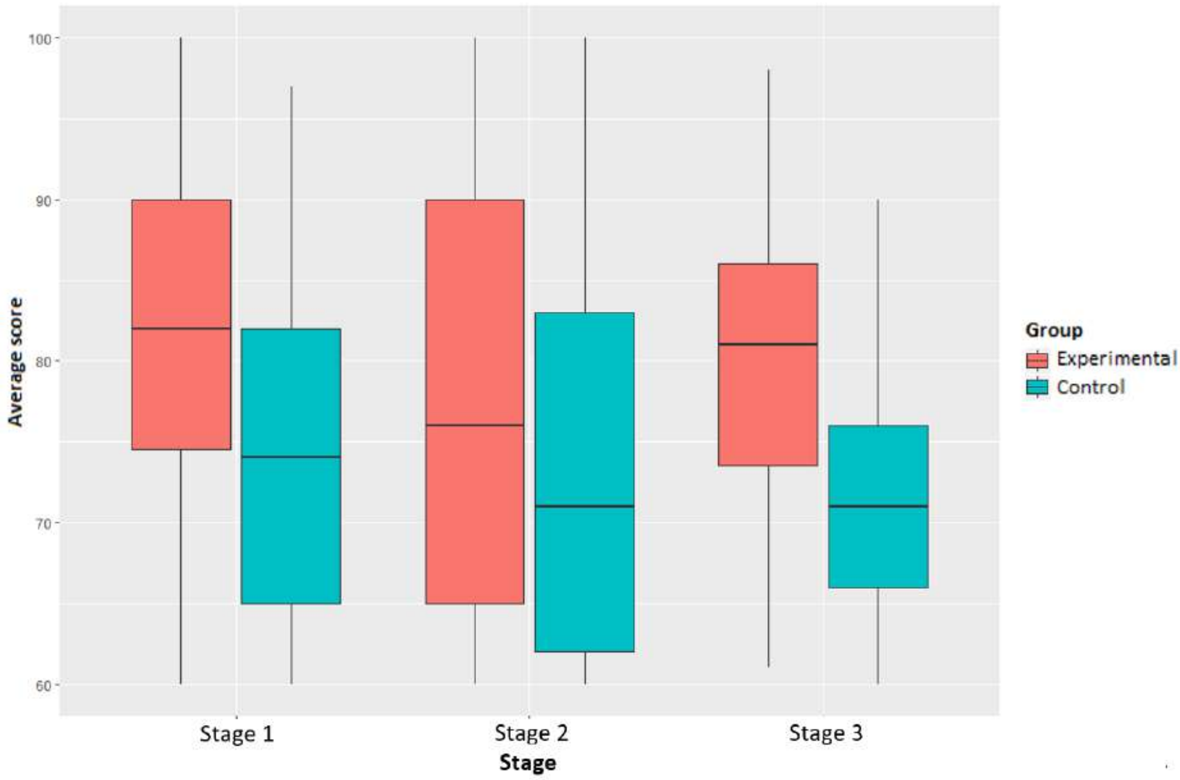

Figure 10: Box plot diagram of grades by stages and groups.

As a result of pedagogical experiment the students' grades increased by 6.4 points, which is confirmed by the results of statistical processing of research results. The developed methodology can be used by higher education institutions for the implementation of project training in the education of future IT professionals.

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The Criteria of Usability Design for Educational Online Courses

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Keywords: Criteria of Usability Design, Online Education, Online Course, Implementing the Usability Principles.

Abstract: The article addresses the issue of implementing the usability principles of educational internet resources. The paper debates the latest researches on the question concerning the search for the factors that influence the results of online education. The analysis, which we carried out, allowed us to focus on such known six criteria of usability design as Information Quality, System Navigation, System Learnability, Visual Design, Instructional Assessment, and System Interactivity and suggest the existence of the seventh criterion named Responsiveness. The research considers the principles of usability implementation following the example of the open platform of online education "Higher School Mathematics Teacher". The answers given by 203 respondents during the survey allowed defining the direction of implementing the usability criteria on the platform. We were eager to know the opinion of teachers and students who became the first users of the platform. The article discusses the criteria implementation while developing online courses on the platform. There was ground to conclude that when designing online platform courses, all seven usability subcategories are important.

1 INTRODUCTION

1.1 Problem Statement

Developing online courses is one way to a sustainable future for our society through education (Vlasenko et al., 2021, 2022). The modern market for online education offers a great number of online courses for educating adults, young people, and children. The subject matter and complexity of such courses differ a lot, but certain development principles and operation of educational internet resources have a lot in common. One of the most important questions while developing any of the sites is its usability. This term is used as a measure of site friendliness, its understandability, and naturalness for the user. Web-site usability is determined by simplicity. Simplicity makes internet resources easy to perceive by users, makes it possible to carry out a fast shift to the necessary content, and facilitates access to information. Therefore, the research of usability issues in educational software is an important aspect of developing distance education.

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1.2 Literature Review

While searching for the factors that influence the results of online education, scientists paid attention to the interface of educational platforms. Nielsen (Nielsen, 1993) was one of the first scientists who used the term usability. He developed a heuristic evaluation – a methodology for researching software usability. The so-called "Nielsen protocol" consists of ten heuristics developed for the software:

(1) The user can detect the system status;
(2) The system uses the terminology, which is convenient for the user;
(3) Free system manageability, support of removal function (undo) and repetition function (redo);
(4) Consistency and standards;
(5) Error prevention and warning the user about further problems;
(6) Load minimization on the user's memory;
(7) Flexibility and efficiency of the usage;
(8) Aesthetic and minimal design;
(9) The system has to offer the user a constructive solution to the issues that arise;
(10) Presence of reference information in the system.

Benson et al. (Benson et al., 2002) increased the number of heuristics up to fifteen when they developed them specifically for electronic education. While designing the systems of electronic education, Srivastava et al. (Srivastava et al., 2009) proved that the attention should be focused on the learning outcomes and not only on satisfying users' interests. The interface has to be attractive and simple to use, but its main task is to enable the user to build their strategy of education. Squires and Preece (Squires and Preece, 1999) offered an approach that integrates the idea of software usability heuristics with the idea of considering the educational results and issues. In scientists' opinion, the main criterion of developing electronic education has to become its reliability. Asarbakhsh and Sandars (Asarbakhsh and Sandars, 2013) named the usefulness of technologies and their usability among the significant factors that should be considered while developing and implementing technologies of online education.

While highlighting and describing six criteria of usability design, Alshehri et al. (Alshehri et al., 2019) formulated and researched these criteria concerning their importance for students:

- Information Quality (IQ);
- System Navigation (SN);
- System Learnability (SL);
- Visual Design (VD);
- Instructional Assessment (IA)
- System Interactivity (SI).

While ascertaining if this list of criteria could be considered full taking into account the possibility to use mobile devices by users, we addressed the statistics data (Enge, 2021). It is clear from the data that 58% of site visits were from mobile devices. 44% of mobile device users visited the sites of the category "Career and Education" and 42% visited the sites of the category "Science". Using the service Google Analytics (Google, 2021) we detected that 35% of users of the platform "Higher School Mathematics Teacher" (formathematics.com, 2019) also use mobile devices. So, while analyzing the statistics we can say that the pattern of growth of website visitors from mobile devices will be kept in the future. Taking this fact into account we considered it necessary to introduce an additional seventh criterion "usability design" for educational web systems called Responsiveness (RS) that would reflect usability for visitors from mobile devices. The relevance of this assumption was checked in the research results.

This article is aimed at analyzing the online course developers' approaches to implement usability, showing usability implementation principles following the example of the open platform of online education "Higher School Mathematics Teacher"

2 METHODS

During the research, the analysis of the resources was used (Nielsen, 1993; Benson et al., 2002; Srivastava et al., 2009; Squires and Preece, 1999; Asarbakhsh and Sandars, 2013; Alshehri et al., 2019; Enge, 2021; Vlasenko et al., 2020c; Antonelli et al., 2015; Aery, 2007; Sánchez-Franco et al., 2013; Kurtcu, 2012; Lin et al., 2013; Mansor, 2012; Shahzada, 2017). As a result of the analysis, seven usability criteria of educational platform were determined.

2.1 The Criterion of Information Quality

The criterion of Information Quality reflects the accuracy, correspondence, completeness and actuality, simplicity of its understanding. The indicator of this criterion mainly depends on the competence of the tutor who creates and supports the online course.

The educational platform should consist of necessary tools so that the tutor can post content of the online course to ensure the information quality. The tutor has to be able to add and edit conveniently text, graphic, animation, video, and audio content, publish documents of standard formats (presentations, mathematical expressions, PDF documents, etc.). The analysis and description of tools for posting an online course are represented in the article (Vlasenko et al., 2020c).

2.2 The Criterion of System Navigation

It is necessary to organize navigation elements, the quality of which reflects the criterion of System Navigation, for fast and convenient navigation through the sections of the educational platform. It implies simplicity and navigation options, link reliability, understandability of action sequence, and easy accessibility.

Interactive elements such as buttons or hypertext links are used for the technical implementation of the navigation system. For convenience, these elements have a separate interface that is different in its color range from the main content and interface. Usually, the navigation elements have interactive characteristics that change while using them in a particular way. For instance, when the cursor moves over the element or clicking the mouse button on the element, its style changes and it makes it clear for the user that this is a navigation element. For making the element clearer, it is necessary to add a tooltip that reflects the name or an abstract of the section that it refers to.

Navigation elements can be united in groups following their structural characteristics. These groups create the main and additional menu, a structural map, or a sitemap. The main menu is usually displayed at the top and the bottom of the interface in order to attract the user's attention to it as it contains a link to the main sections of the educational system (Antonelli et al., 2015). The structural map of the educational platform includes a complete hierarchy of references to the sections, subsections, and content that enables the user to navigate to any page of the hierarchy.

Navigation chains (so-called "breadcrumbs") that allow us to visually represent the hierarchy of top-level pages and navigate on them are displayed on every page for ease of navigation. (Aery, 2007). This element is particularly important when there are a great number of pages that are put one in another.

The reliability of links reflects the absence of navigation elements that refer to the non-existing content or section. This situation takes place when the operator gives the wrong reference system or content is deleted from the system without updating the navigation structure. For preventing the reliability decrease planned verifications of navigation structure with the help of special software (Screaming Frog SEO Spider Tool, Netpeak Spider, SiteAnalyzer, etc.) or manual testing is used.

The ease of navigation increases while implementing on the educational platform a search system that helps the user to navigate fast to the necessary content following the formed request. The search elements can be displayed at the top of the interface and additionally in a sidebar or at the bottom.

2.3 The Criterion of System Learnability

The criterion of System Learnability characterizes learning simplicity and promptness. Similar to the criterion of information quality, it depends on the online course developer's competence. The criterion includes learning simplicity, predictability of links, and learning without any initial preparation, formulation accuracy, and sufficient online assistance.

In order to ensure System Learnability, the tutor has to determine clear aims and objectives of learning an online course, create a learning program according to the aims and objectives, develop the structure, content, forms, and methods of knowledge control, determine criteria of knowledge assessment, describe requirements for task completion, and ensure control over the learning process, keep in touch with course participants in form of private or group online consultations.

2.4 The Criterion of Visual Design

Apart from the quality of text, graphic, and multimedia information, the educational platform needs to have aesthetic attractiveness and convenient location of system interface elements (Sánchez-Franco et al., 2013) that enables users to perceive adequately the provided information. The criterion of Visual Design is an integral part of evaluating the interface of any information system. It includes readability, design aesthetics, quality of template structure, and typography, and the sequence of posting information on the educational platform.

In order to ensure design aesthetics general principles of interface creation are used. A general template of displaying information blocks is chosen and it usually has a header, footer, sidebar, and block of the main content. A logo or name of the educational platform is displayed at the top of the interface. Typography that determines text view is chosen. A font with notches or without, a particular style display for headings, subheadings, and main text can be used (Kurtcu, 2012). The main color range in RGB model coding is determined. Usually, light colors are used for the background, dark colors for the main content, and additional colors for structural elements and links. For the sense of use simplicity and clarity, the ratio between qualitative use of graphics and text is recommended to be used proportionally from 3:1 to 1:1 (Lin et al., 2013).

2.5 The Criterion of Instructional Assessment

The criterion of Instructional Assessment reflects the efficiency of assessment tools, simplicity of their use, feasibility of achieving educational aims, accessibility for material understanding, and informative nature of feedback.

For the implementation of this criterion on the educational platform tools for assessment and self-assessment are implemented and integrated: testing, survey, task sending, feedback forms, assessment book. Cloud services such as Google Forms, FormDesigner, Typeform, MyQuiz, etc. can be used for most of the indicated assessment methods (Mansor, 2012). The alternative to cloud services can be an individual development of assessment subsystem using a corresponding programming language and framework frontend (React.js, Angular, jQuery, Node.js, and others). In this case, data is stored on the server in the database, and access to them is ensured using the authorization mechanism and distribution of users' roles.

2.6 The Criterion of System Interactivity

The criterion of System Interactivity reflects the quality of interaction between participants of the educational process. This criterion includes the efficiency of communication tools, implementation of interaction tutor-student, student-student. Interaction tutor-student can be implemented using modern Internet services that are integrated into the educational platform.

For text communication emails, web-forums, messengers (Telegram, Viber, WhatsApp, etc.), and social networking sites (Facebook, Twitter, LinkedIn, etc.) are used. It often occurs that not only one but several services are used together. Emailing or push-messages are used to send organizational messages. Visual communication is implemented using the system of video-conferences (Zoom, Microsoft Teams, Google Meet, etc.). The file exchange can be done using cloud storages (Dropbox, OneDrive, Google Drive, iCloud, etc.), emails, and messengers. However, email services have limits for the size of files that are sent and filtering according to the file types (for instance, archives, executable files). That's why email is not convenient for this purpose. Messengers also have a considerable disadvantage that is explained by the fact that sent files are stored on the participants' devices but not on the server. This factor indicates the unreliability of this method because, in case of changing or damaging a device or accidental removal, files can be lost forever. Nowadays, cloud storages are the most reliable and convenient method for file exchange. The criterion of System Interactivity will depend on choosing the best combination of the described communicative services and their technical integration in the educational platform.

2.7 The Criterion of Responsiveness

The criterion of Responsiveness reflects the quality of aesthetic interface display of the educational platform on mobile devices that have different resolutions. As the number of users of mobile devices is constantly growing, this criterion is important nowadays. The criterion includes the responsiveness of the layout, image, media, menu, and navigation elements.

In order to ensure the responsiveness of the platform design, methods to represent the interface using stylization CSS (Cascading Style Sheets) for particular device capabilities are used. In this case, the interface has several visualizations that are created particularly for devices following their screen resolution. Sometimes several options of the interface posted on separate Internet subdomains are used to support design responsiveness. But this variant is not an optimal solution, since it is necessary to make changes in all interface variants if the platform functionality is enlarged or changed.

Using stylization CSS the template of posting information blocks is changed but the interface elements have a different view on mobile devices, tablets, and computers. The size of the text, headings and subheadings, links, buttons, image size, and other interface elements are adapted following this criterion. Modern programming frameworks (Bootstrap, Angular, React, Node.js, etc.) can be used to implement Responsiveness (Shahzada, 2017).

3 RESULTS

The above-mentioned parameters were included in the survey of higher school teachers and students. The survey was aimed at getting the respondents' assessment concerning the usability and simplicity of online courses on educational platforms that are used by the respondents. The survey was divided into two parts. In the first part, there were questions concerning the information about the respondents, such as sex, age, status (teacher, student), their experience of using online courses and educational platforms on which they took online courses, and the aim of online education. This information was gathered to get descriptive statistics of research selection and selection of educational online platforms for the analysis. The second part of the survey included the questions concerning the relative importance (value) of the determined usability categories and subcategories and category ratings for users.

This section included 35 elements divided into seven parts. We had to determine the category place from 1 to 7 depending on its impact on the platform usability (where 1 is the most important). Getting a smaller evaluation rate of the corresponding feature of usability demonstrates its greater importance for teachers and students during the online course. Subcategories have to be evaluated using a 3-point scale where "–1" affects the criterion, "0" does not affect the criterion at all, "+1" has a positive effect on the criterion.

The survey was held directly by the tutors of the educational online platform "Higher School Mathematics Teacher" in higher schools. 246 participants took part in the survey, among them 85 teachers and 161 students of Donbas State Engineering Academy, Volodymyr Dahl East Ukrainian National University, Kryvyi Rih State Pedagogical University, Donbas National Academy of Civil Engineering and Architecture. It must be said that 43 participants (18 teachers and 25 students who constituted 17.4% of the respondents) stated that they had never used online education. Therefore, the final number of respondents is 203 participants – 67 teachers and 136 students.

We offer to consider the division of respondents according to their age and sex in table 1.

According to the survey results in table 2, the majority of respondents (70.9%) studied the online courses in higher schools developed using the distance learning system Moodle (Polhun et al., 2021). Furthermore, the respondents used the platforms Prometheus (Prometheus, 2019), EdEra (EdEra, 2019), The Open University (The Open University, 2019), Edx (EdX, 2019), Coursera (Coursera, 2019), Intuit (Intuit, 2019) for education (respondents had a possibility to name several educational resources).The aim of the education determined by the majority (68.9%) was the current education; moreover, skills development – 23.8%, acquiring additional skills – 3.1%, personal development – 4.2%.

We offer to consider the categories and subcategories from the other survey part. We have found out the importance of the defined categories and subcategories for users, their usability, and rating.

Category 1 – System Navigation (SN), subcategories:
- 1.1 Ease of navigation
- 1.2 Navigation support
- 1.3 Reference reliability
- 1.4 Understandability of action sequence
- 1.5 Ease of access

Category 2 – Information Quality (IQ), subcategories:
- 2.1 Ease of education
- 2.2 Reference predictability
- 2.3 Education without any initial preparations
- 2.4 Formulation clarity
- 2.5 Sufficient online assistance

Category 3 – Visual Design (VD), subcategories:
- 3.1 Readability
- 3.2 Design aesthetics
- 3.3 Layout information content
- 3.4 Presentation structure
- 3.5 General course consistency

Category 4 – System Learnability (SL), subcategories:
- 4.1 Information correctness
- 4.2 Information conformity
- 4.3 Information completeness
- 4.4 Ease of information understanding
- 4.5 Information timeliness

Category 5 – Instructional Assessment (IA), subcategories:
- 5.1 Evaluation tools efficiency
- 5.2 Ease of using evaluation tools
- 5.3 Reality of achieving learning objectives
- 5.4 Accessibility for material understanding
- 5.5 Feedback Information content

Category 6 – System Interactivity (SI), subcategories:
- 6.1 Efficiency of communication tools
- 6.2 Implementation of communication between the tutor and student

Table 1: Division of respondents according to their age and sex.

Characteristics	Teacher		Students		Total	
	number	%	number	%	number	%
sex						
male respondents	35	52.2	84	61.8	119	58.6
female respondents	32	48.8	52	38.2	84	41.4
age						
under 30	3	4.5	136	100	139	68.5
31-50	42	62.7	0	0	42	20.7
over 50	22	32.8	0	0	22	10.8

Table 2: Online platforms where respondents studied.

Characteristics	Teacher		Students		Total	
	number	%	number	%	number	%
Moodle-based LMS	14	20.9	130	95.6	144	70.9
Prometheus	8	11.9	2	1.5	10	4.9
EdEra	16	23.9	-	-	16	7.9
The Open University	4	6.0	1	0.7	5	2.5
Edx	4	6.0	2	1.5	6	3.0
Coursera	18	26.9	-	-	18	8.9
Intuit	7	10.5	5	3.7	12	5.9
Other platforms	4	6.0	3	2.2	7	3.5

6.3 Possibility of communication student-student

6.4 Interaction organization

6.5 Feedback speed

Category 7 – Responsiveness (RS), subcategories:

7.1 Flexible layouts (website layout that will dynamically resize to any width)

7.2 Flexible images (scalable images)

7.3 Flexible media (scalable images, video, and other formats)

7.4 Flexible menu

7.5 Flexible navigation

Respondents selectively evaluated each of the online courses on 7 usability criteria. Each criterion was evaluated on a scale from 1 to 7 (where 1 is the most important, 7 is the least important). Based on these results, the average values for the usability criteria for each of the online courses were found. The results of the respondents' evaluation of usability criteria are provided in table 3. In addition, the average estimates of the significance of the criteria for all online courses that were selected are presented in figure 1.

The results analysis helped us to confirm the assumption about the necessity to consider one more criterion. The respondents recognized the greater importance of the criterion Responsiveness rather than the criteria Instructional Assessment and System Interactivity.

Figure 1: The distribution of places categories from 1st to 7th depending on their impact on the usability of the platform (where 1 is the most important).

We offer to consider the evaluation results of the importance of usability subcategory in table 4.

According to the results, we can conclude that all the usability subcategories are important because any of them has a negative average rating.

4 DISCUSSION

While researching the usability of educational platforms, scientists marked site usability as an important element of developing educational platforms.

Inductive Content Analysis Method helped to determine the direction of implementing usability criteria on the platform "Higher School Mathematics

Table 3: Respondents' evaluation of online education systems according to Usability design criteria.

Systems of online education	Criteria						
	IQ	**SN**	**SL**	**VD**	**IA**	**SI**	**RS**
Systems of distant education based on Moodle	1.31	2.3	3.17	3.99	6.11	6.87	4.56
Prometheus	1.18	1.87	2.95	4.02	5.89	6.76	4.81
EdEra	1.04	2.12	3.01	3.68	6.03	6.94	5.12
The Open University	1.24	1.97	2.76	4.17	5.84	6.63	5.26
Edx	1.11	2.07	3.24	4.31	6.24	6.80	5.08
Coursera	2.13	3.14	1.05	3.79	5.26	6.48	4.74
Intuit	2.41	1.27	3.15	4.02	4.87	6.81	4.86

Teacher". We agree with Alshehri et al. (Alshehri et al., 2019) that the most important criterion of usability design is Information Quality that describes the correspondence of the information in the system to learners' needs. We have also considered point of view of Nielsen and Loranger (Nielsen and Loranger, 2006), who point out that the efficiency of any application work and its attractiveness for the user depend on the search engine and navigation, downloading speed, menu design. In the authors' opinion, the focus on the user, their needs, and requests have to be principal. This idea is agreed with the conclusion provided by Hodakov and Boskin (Hodakov and Boskin, 2017) in which they believe that the adaptive user interface is the main criterion of computer system attractiveness. Such interface reflects the capability of a simple software product or a complicated program technical complex to adapt to the user's needs, consider their psychophysical characteristics and abilities, dynamic change, support the consolidation of common actions to solve the given task.

The ranking results are presented in the diagram (figure 1).

While analyzing categories and subcategories we paid attention to the research by Dringus and Cohen (Dringus and Cohen, 2005) who defined 13 heuristic categories that influence the usability of the educational environment on the Internet. They include visibility, functionality, aesthetics, feedback and assistance, mistake prevention, memory, course management, interactivity, flexibility, consistency, efficiency, mitigation, contraction, and accessibility. While researching the criteria of evaluating the usability of the electronic educational system, Fang and Holsapple (Fang and Holsapple, 2007) highlighted system navigation, performance system, visual design, information quality, instructive assessment, and system interactivity. Following the results of their research, information quality is the most important criterion; navigation in the system of electronic education takes the second place. Instructive assessment and system interactivity are the least important design categories that influence the usability evaluation of the electronic educational system. In order to consider the concept of the platform "Higher School Mathematics Teacher" (formathematics.com, 2019), according to which we have to take into account the wish of different age audience of online courses, we followed the recommendations by Hasan (Hasan, 2014) who studied the usability of educational websites from university students' perspective. The scientist defined that the content and navigation are the first and second desirable design categories that have to be considered during the usability evaluation of websites for educational programs while organization and architecture are the least important categories.

Research conclusions reached by Vlasenko et al. (Vlasenko et al., 2019, 2020a,b) and the analysis of the results of teachers' and students' survey allowed determining the direction of implementing usability criteria on the platform "Higher School Mathematics Teacher" (formathematics.com, 2019).

First of all, we found out how we can implement the criterion *Information Quality* (IQ) that describes the information correspondence in the system to learners' needs and the criterion *System Learnability* (SL) that characterizes education simplicity and rapidity. The quality of these criteria depends on the tutor's competence that creates and supports the online course. In order to create high-quality content following the criteria IQ and SL, the tutors of the platform "Higher School Mathematics Teacher" (formathematics.com, 2019) are given a possibility to use software tools to format the text, insert graphics, video- and audio information, insert links, formulas, tests, surveys. Vlasenko et al. (Vlasenko et al., 2020c) and Panchenko et al. (Panchenko et al., 2020) described the application use during the development of the educational online platform.

The criterion *System Navigation* reflects the quality of navigational tools. On the platform, it is formed with the help of main and additional menus that are posted at the top of the interface and are present on every page. Their presence allows the user to navi-

Table 4: Respondents' assessment of the usability subcategory importance.

Usability subcategories	Average estimate
1.1. Ease of navigation	0.91
1.2 Navigation support	0.72
1.3 Reference reliability	0.64
1.4 Understandability of sequence of actions	0.78
1.5 Ease of getting access	0.81
2.1 Ease of education	0.88
2.2 Reference predictability	0.42
2.3 Education without any initial preparations	0.56
2.4 Formulation clarity	0.71
2.5 Sufficient online assistance	0.65
3.1 Readability	0.57
3.2 Design aesthetics	0.74
3.3 Layout information content	0.63
3.4 Presentation structure	0.59
3.5 General course consistency	0.47
4.1 Information correctness	0.81
4.2 Information conformity	0.67
4.3 Information completeness	0.52
4.4 Ease of information understanding	0.87
4.5 Information timeliness	0.62
5.1 Evaluation tools efficiency	0.42
5.2 Ease of using evaluation tools	0.37
5.3 Reality of achieving learning objectives	0.93
5.4 Accessibility for material understanding	0.86
5.5 Feedback information content	0.72
6.1 Efficiency of communication tools	0.62
6.2 Implementation of communication between the tutor and student	0.71
6.3 Possibility of communication student - student	0.69
6.4 Interaction organization	0.53
6.5 Feedback speed	0.74
7.1 Layout flexibility	0.85
7.2 Image scaling	0.78
7.3 Media scaling	0.81
7.4 Menu flexibility	0.67
7.5 Navigation flexibility	0.91

gate to the necessary section. In order to provide a clear sequence, "breadcrumb" navigation is posted on the pages and allows representing visually the hierarchy of top-level pages and navigating all over them. The presence of such an element is especially important when there are a great number of pages that are put one in another. Ease of navigation is also provided by the presence of links directly in the content of the educational text.

The criterion *Visual Design* reflects the aesthetics of displaying the educational system. In order to ensure readability and aesthetic design the following basic color scheme in the RGB model coding was determined: light colors for the body (#FFFFFF, #F0EAEE), dark color for the main content (#333333), and additional colors for structural elements, for links (#993333, #B8999F, #D6DDE3). The general structure of the platform interface includes a header, footer, sidebar, and content layout elements. This structure corresponds to the purpose of the platform information content. Typography was chosen to provide the text and it includes the text without any notches, a particular style display for headings, subheadings, and the main text.

The criterion *Instructional Assessment* reflects the simplicity and efficiency of evaluation tools. This criterion is provided using feedback forms, subsystems of testing, survey, and file downloading. Feedback forms are used both for educational and general questions.

The criterion *System Interactivity* reflects the presence of simple tools of interaction among participants of the educational process. In order to correspond to this criterion the forum of the platform users that ensures the interaction student-teacher, teacher-student, and student-student was implemented.

The criterion *Responsiveness* reflects the quality, aesthetics of system display on mobile devices that have different resolutions. In order to ensure the adaptability of platform design, methods of the interface presentation using stylization CSS for particular separate capabilities of the devices are used. The elements of the menu and sidebar interface have a particular view on mobile devices. Text size, headings and subheadings, links, buttons, image size, and other interface elements were adapted to correspond to this criterion.

Localization and customization are also important in order to implement usability. The adaptation of mass products on demand of a particular customer on the educational platform "Higher School Mathematics Teacher" takes place through partial content change following a particular request, additional staffing of the course with extra activities and materials. Platform tutors monitor regularly discussions concerning the courses on the "Teachers' forum", react promptly to offers made by the users of the course. The development of new courses is also based on studying requests and wishes made by platform users.

5 CONCLUSIONS

The actuality of researching the usability issue in educational software as a direction of developing distance education arises from the growth of the modern Internet education market. This implies particular requirements concerning the usability of online courses.

The Inductive Content Analysis Method helped us review the existing researches concerning the criterial basis of usability design. This method also helped to define the actual usability criteria of the educational platform as well as to provide an assumption about the necessity to consider the criterion driven by the presence and active use of mobile devices.

In order to clarify the hypothesis, we developed a survey for teachers and students who are online course users. The analysis of survey results was held in two directions: to get descriptive statistics of online course users and study the relative importance of evaluating categories of educational platform usability. Such an approach to the survey allowed getting substantial information concerning the preferences of online course users that should be taken into consideration during its development.

Therefore, according to the research results, we found out that it is worthwhile to add the criterion Responsiveness that reflects the usability of mobile devices for online education. So, according to the results of researches and surveys, we offer the next order of usability criteria in descending order:

1. Information Quality (IQ);
2. System Navigation (SN);
3. System Learnability (SL);
4. Visual Design (VD);
5. Responsiveness (RS);
6. Instructional Assessment (IA)
7. System Interactivity (SI).

Further research will be aimed at the usability criteria analysis of the educational online platform "Higher School Mathematics Teacher".

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Methodical Recommendations for the Development of Online Course Structure and Content

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Abstract: The article looks into the matter of developing methodical recommendations for the structure and content of online courses. The research is dedicated to the analysis of peculiarities of developing the content of online systems and developing methodical recommendations for educational materials of online courses. The research considers the experts' experience in preparing, structuring, and developing the content of online courses and answers to the volunteers who have agreed to test the educational materials of the course "Methods for Teaching Mathematics to Students in Technical Universities" http://formathematics.com/courses/imt/mnmtzvo-en/. The participants' responses have allowed evaluating the quality of the developed course and detecting its insignificant drawbacks. The article discusses general requirements for the structure and content of the online course, means for the implementation of a testing subsystem, peculiarities of developing educational video content and educational materials in PDF format, issues of implementing forum and survey subsystems, as well as means of assessing learning outcomes. We have grounds to conclude that the quality of the course is determined by the range of factors, among which we point out the course organization based on weekly planning, implementation of a testing subsystem under conditions of extended functionality, creation of abilities to organize feedback.

1 INTRODUCTION

1.1 Problem Statement and Its Topicality Substantiation

The emergence of available web-technologies has dramatically changed the approaches to communication and education. The access to the Internet and the variety of gadgets that allow this access led to the demand for educational services that adapt to the needs of learning during life ensuring the personalization of the learning process. Such demand en-

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couraged the creation of the educational trend – the development of open educational online-platforms. The implementation of the idea of open online education requires the development of recommendations both as technical and methodical support of online courses. Thanks to them a considerable number of people can increase their qualification or develop professional expertise. Supporting the idea of accessible educational opportunities, we have studied experts' experience in preparing educational materials. By implementing numerous recommendations concerning the preparation, structuring, and development of the content for online courses, Writing and Structuring Online Learning Materials (Leicester Learning Institute, 2019), DIGICOMP (DIGICOMP, 2015) and Leicester Learning Institute (Leicester Learning Institute, 2020) remind us that we live a life of constant changes and these changes have to influence teaching and learning. To implement these changes in the system of online education, we have to provide educational materials that meet students' expectations. This means that giving learners the possibility to acquire some particular skills via online courses requires serious training. Therefore, the topicality of the issue to develop methodical recommendations for the structure and content of online courses is not questionable.

1.2 Literature Review

To determine recommendations for developing an online course, we have studied practical recommendations by FAO (FAO, 2021) who considers that the development of any course has to encourage the creation of practitioners' community and support their willingness to cooperate. While planning the development of the materials necessary for the implementation of particular types of work we paid our attention to the possibility to plan the achievement of educational progress. At the stage of planning the aims, we were focused on the concept of the platform "Higher School Mathematics Teacher" (formathematics.com, 2021), developed by Vlasenko et al. (Vlasenko et al., 2019a). Taking into account scientists' opinion while preparing the curriculum we were focused on the achievable goals, believing that the students' achievement of aims regularly will encourage their motivation to aspire to more. While developing the lectures we were interested in the researches conducted by Dommeyer et al. (Dommeyer et al., 2004), Deming et al. (Deming et al., 2015), Bauer (Bauer, 2019), who describe in their works the improvement of lecture materials using the survey of the respondents who work with courses. Cruse (Cruse, 2019), Suduc et al. (Suduc et al., 2010), Suduc et al. (Suduc et al., 2012) recommend giving video lectures. Confirming the efficiency of using videos in the educational process, among the greatest advantages of its use the scientists emphasize the possibility of course participants to learn the material according to their pace of assimilating the educational materials. Moreover, in scientists' works, there is evidence that video content ensures a greater emotional impact on participants in comparison to the text-based one. Developing tests that according to Suwatthipong et al. (Suwatthipong et al., 2015) have to accompany learning theoretical materials we considered scientists' opinion that testing should both help to assess the progress level while assimilating the educational material and help to acquire new knowledge. Being acquainted with the research in which Wrigley et al. (Wrigley et al., 2018) compared the content quality of Massive Open Online Courses, we concluded that while developing course materials it is necessary to evenly distribute labor intensity of students' learning activities by weeks, providing the interaction among the participants. Furthermore, we took into consideration the results of the research by Jönsson (Jönsson, 2005), Vlasenko et al. (Vlasenko et al., 2020e), where it is justified that the efficient online course includes the integration of various web tools (Vlasenko et al., 2020e) and resources for learning the course material.

Thus, giving recommendations for the presentation of educational materials during online courses, every scientist stated that there should be a specific approach for the development and certain nuances should be considered. So, the article is aimed at carrying out a theoretical analysis of peculiarities of the existing online systems and the development of methodological recommendations for the development of structure and content of online courses on the platform "Higher School Mathematics Teacher" (formathematics.com, 2021).

2 METHOD

The analysis of the content on open educational platforms, the world experience of implementing online learning, the synthesis of the results after such an analysis, and our own experience allowed forming methodological recommendations for the preparation of online courses.

We have surveyed master students (the qualification code of the program "014.04. Secondary Education. Mathematics") and higher school mathematics teachers to find out the quality of educational materials for the online course "Methods for Teaching Mathematics to Students in Technical Universities", published on the platform "Higher School Mathematics Teacher" (Lovianova et al., 2021). The theoretical analysis of the researches and resources that implement the recommendations, content structuring and development of online courses, analysis of respondents' answers to the survey questions published on the platform forum has influenced the description of the methodical recommendations for the structure and content of online courses. To explore the resources, we analyzed the structure and content of the most popular Massive Open Online Courses (MOOC). When selecting resources, we focused on the online courses (LinkedIn, 2019; Udemy, 2019; Coursera, 2019; EdX, 2019; FutureLearn, 2019) included in the Top Tools for Learning 2019 (Centre for Learning & Performance Technologies, 2021).

Having analyzed the resources, we found several sections that the online courses include and the average course duration. We were eager to know how often titles are offered and what the purpose of testing in courses is. We have highlighted the peculiarities of video lectures, training materials in PDF format. Particular attention was paid to the organization of the course process and feedback from students. Through content analysis, we have developed methodological recommendations for the development of structure and content of online courses on the platform "Higher School Mathematics Teacher" (formathematics.com, 2021).

2.1 The Presentation of the Course Taking into Account the Peculiarities of an Online Presentation

At the beginning of education on open online platforms, the user should clearly understand how they will learn and what material they will work with.

Following the recommendations of dividing online course content into sections, subsections (topics), pages, and components (Vlasenko et al., 2020d), we concluded that the construction of an online course should be based on weekly planning, where sections are formed on the principle of combining materials that are learned during one or several weeks.

We have also considered that educational methodical online courses have to include no more than 6 sections. Every section has to include one or more pages; the page has no more than one component. For instance, the online course "Methods for Teaching Mathematics to Students in Technical Universities", published on the platform "Higher School Mathematics Teacher" (Lovianova et al., 2021), includes three sections with three topics for each one. At the same time, the course "Project Method in Teaching Higher Mathematics" (Kondratieva et al., 2019) includes 6 sections with 2 topics for each (figure 1), and the course "Personal E-learning Environment of the Maths Teacher" (Vlasenko et al., 2019b) has 5 sections with 2 topics for each (figure 2).

The number of sections and topics depends on the course volume and the preliminary survey of teachers and students (course users) who help to determine the course structure.

2.2 Structuring

Before creating the course it is necessary to have a clear understanding of the course's target audience, main needs, and peculiarities of this audience. So, tutors have to determine the aims of learning and anticipated results, subject, structure, assessment criteria, and organization of feedback. It significantly influences the content and structure of the course. Moreover, it is necessary to consider when and how the course users will learn. Also, it should be considered how often it is needed to update the learning material, how much time the tutor will spend on the organization of education and feedback. If there has to be a significant number of users, it is necessary to think about the automatization of these processes.

The structure of the course should be logical, clear, intuitively understandable. While creating the course the following points should be considered:

1) the learning material of the course has to be divided into logical sections, or according to the topics (figure 3), or of a particular length to learn it during 1-2 hours (typical learning class);
2) the headings of sections, topics, and subtopics should be well formulated, it will help users to plan which sections they will work over at every class, and will allow them to skip topics that they already know;
3) before providing the material for every new topic or section it is necessary to give a review of the coming material, its structure, results of learning, and approximate time of learning, it is relevant to give such material in form of a short video;
4) pretesting or final testing after learning a particular topic or section can be conducted on request.

The first three recommendations were considered during the development of all the courses of the platform (formathematics.com, 2021). The online course "Methods for Teaching Mathematics to Students in Technical Universities" (Lovianova et al., 2021) includes both the pretesting on Higher Mathematics and

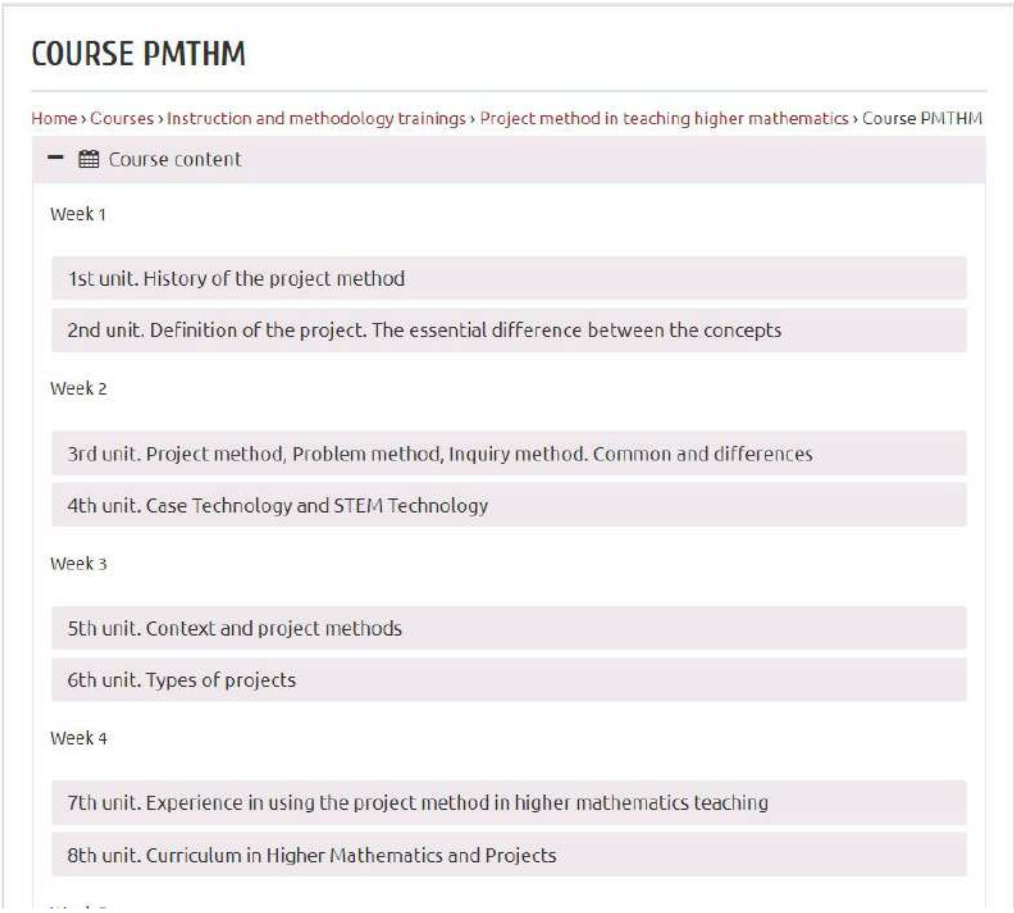

Figure 1: Structure of the course “Project Method in Teaching Higher Mathematics”.

the final course testing. Pretesting is included in the course as it is impossible to succeed during the test without learning the corresponding sections of Higher Mathematics.

2.3 Features of Writing

The educational materials should be taught in an accessible and clear form. Taking into account the peculiarities of perceiving the electronic information (Kondratieva et al., 2019), the material that will be posted in the electronic format should be 50% shorter than the analog, printed one. Therefore, more tables, schemes, corresponding examples, and researches on a particular subject should be used. Additional material should be given as a hyperlink or a separate document.

Besides, it is necessary to explain every new definition or term. It can be a context tooltip, footnote, hyperlink, etc. Also, it is relevant to create a separate glossary for every section or topic.

To give the main theoretical information on the topics during the online course, we use educational materials in PDF format that ensures compatibility and absence of distortions in published materials of the course. Moreover, using PDF format allows the participants to download educational materials to their proper computers for a further acquaintance without any preview on the web-page (Panchenko et al., 2020).

While creating educational materials in PDF format it’s necessary to follow the requirements for presenting documents: to use headings, lists, images with sighs, to represent table data in the form of tables. To type text material the direct (regular) font, which ensures easier perception of information, should mainly be used. The main text should be aligned to the page width. It is not recommended to use formatting with the help of indent and tabulation, multi-column page making, blank line. While using hyperlinks it is necessary to consider that all hyperlinks should be represented as a text in the sentence to increase readability.

For instance, the course “Differential Equations” (Sitak, 2018) widely uses hyperlinks and popup notes

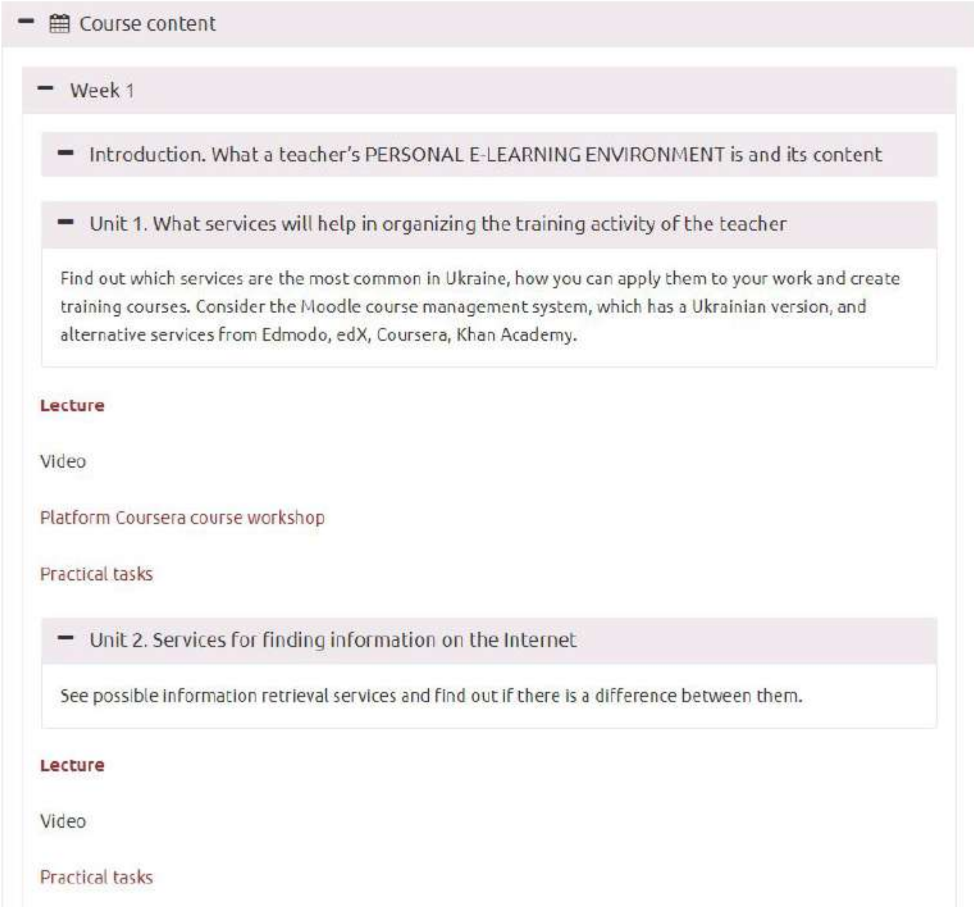

Figure 2: Structure of the course “Personal E-learning Environment of the Maths Teacher”.

(figure 4), while the course “Operations Research-Oriented to Cloud Computing in the System CoCalc” (Bobyliev et al., 2020) offers smaller documents in PDF-format that can be downloaded by students for further use.

2.4 Bright Presentation of Material

To attract attention to online courses and support students’ interest it is relevant to use all the possible means of material delivery – animation, video, multicolored unusual fonts, footnotes, popup tooltips. The relevance of using the side framework to add information is proven.

If it is necessary to publish a considerable amount of educational material directly on the page of the online course, it should be “divided” into parts following the screen size, the navigation and hyperlink system should be organized and an additional PDF-version to store and print the learning material should be created.

The necessity to do group tasks, analyze and assess other course participants’ work adds up to the users’ interest and will encourage the regular analysis of the learning material and periodical review. While giving the material it is relevant to repeat the key concepts, ideas, and theories several times in different forms (if it is possible).

According to the recommendations, materials of the online courses “Project Method in Teaching Higher Mathematics” (Vlasenko et al., 2020c), “Personal E-learning Environment of the Maths Teacher” (Vlasenko et al., 2020a), “Methods for Teaching Mathematics to Students in Technical Universities” (Lovianova et al., 2021), published on the platform “Higher School Mathematics Teacher” (formathematics.com, 2021) are given using video files, hypertext, demonstrative animation, audio lectures, video lectures, schemes, images, graphics, tables, drawings, information reference material (figure 5). Also, presentations and other extra materials such as attached files and interactive supplements, sources that are given in the reference list, are used.

We use video content to get participants acquainted with the aims and resources of the course

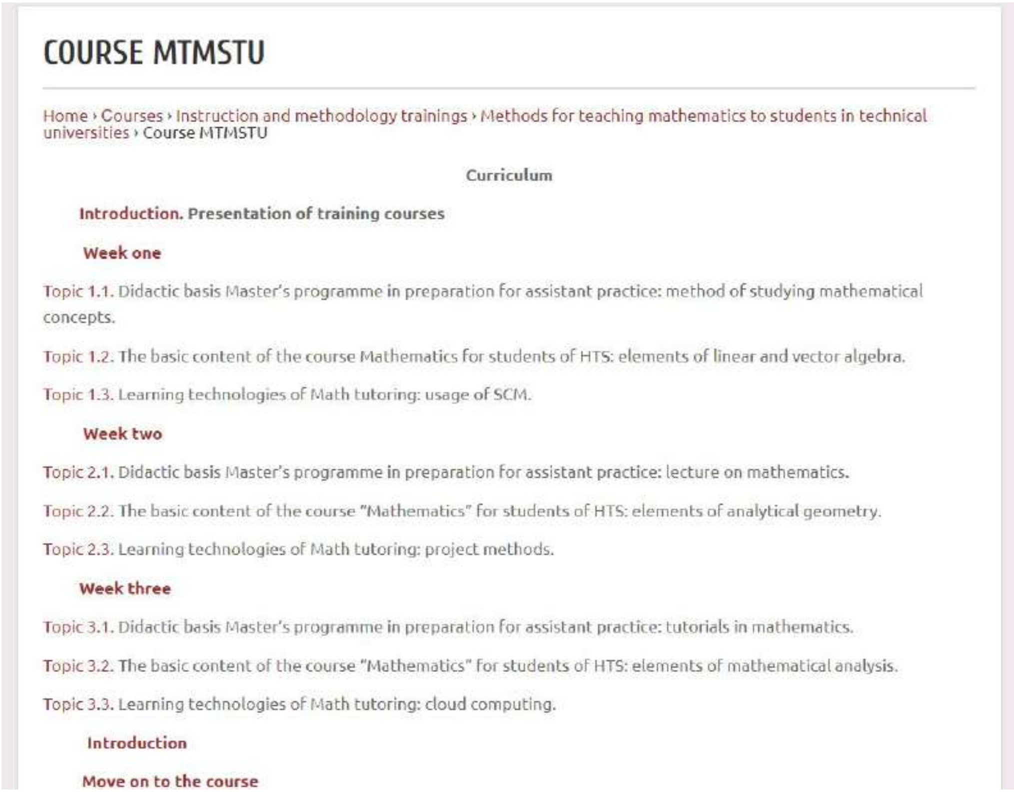

Figure 3: Sections of the course “Methods for Teaching Mathematics to Students in Technical Universities”.

as well as highlight particular topics. Video lectures focus on the main moments of learning material, disclose the topic of the material, and summarize the main conclusions. While creating video lectures it is expected to highlight semantic blocks (video clips) lasting from 3 to 10 minutes that will be watched by the participants during the online course. The image should be high-quality, the text that is demonstrated on the slides should be available for reading from the mobile device screen. Pure sound requires minimal background noise, clear pronunciation of words, and a stable level of volume. While creating video lectures it is preferable to use the universal format of video files MP4.

To create videos during the online course “Methods for Teaching Mathematics to Students in Technical Universities” (Lovianova et al., 2021), we used software Camtasia which implements capturing the video from the screen. Among the main functional abilities of this video editor, which is used while developing educational video, we can highlight providing the recording of the image from the screen including recording sound effects from the microphone or speakers and editing a new video without installing additional software.

To publish video content on the pages of the online course, we used the video from the file directly on the administrator’s panel of the electronic platform without involving extra services. Using such a method of integration ensures the possibility to control the size of the video player and to add extra settings.

2.5 Organization of the Learning Outcome Assessment

While developing the course special attention is paid to the creation of a system to assess the learning results. It can be a constant assessment such as tests and or completing control tasks with saved results (such a system encourages the constant interest in the course completion). It is possible to use the final test on the formed competencies such as certified testing or qualified work. Let’s mention that such an assessment method requires special students’ motivation for test completion.

The course developer has to indicate how much time they need to check the tasks if there were given, when, and how the student can get a certificate or another learning result.

For example, in order to implement the testing subsystem on the platform “Higher School Mathematics Teacher” (formathematics.com, 2021) a pro-

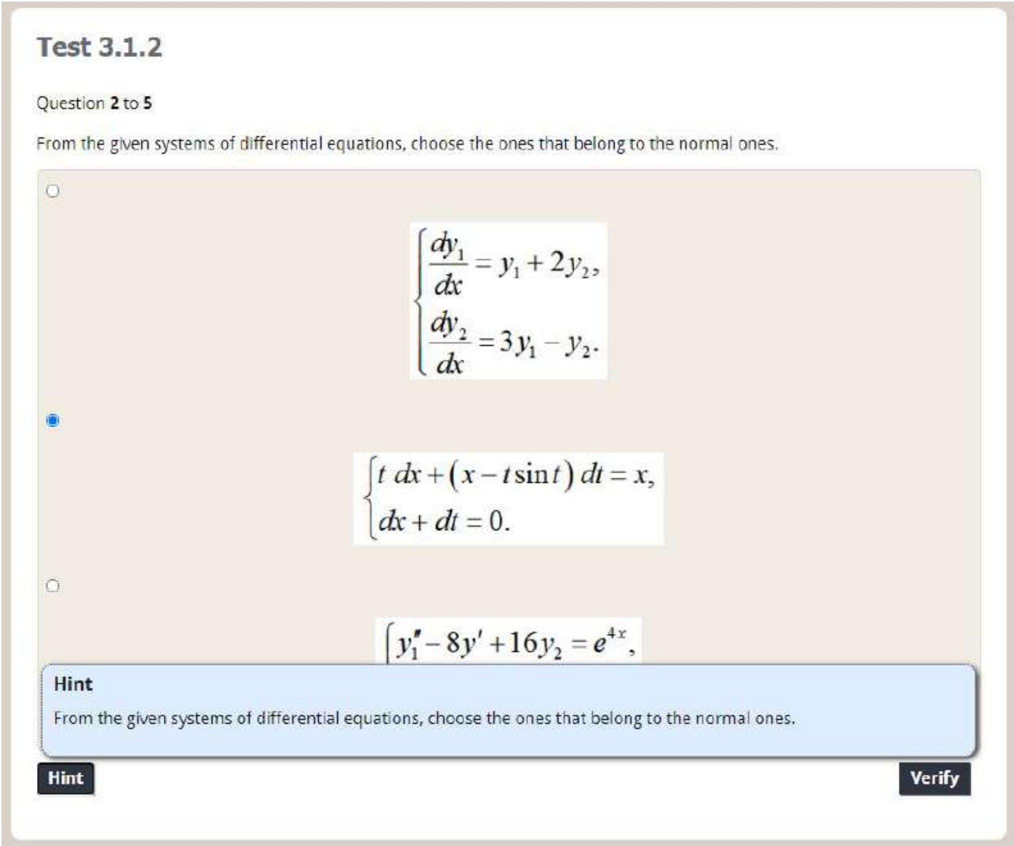

Figure 4: Popup notes in the course "Differential Equations".

gram application for extending functionality was used – the plugin "WP-Pro-Quiz" that ensures flexible settings of the responses options and provides related information.

While creating test questions it is stipulated that information about the number of points for the right answer is provided and the type of answer (single choice, multiple-choice, open choice, etc.) is indicated. Also, there is a possibility to add hints to a particular question. After creating and setting up the test it is possible to publish it on any page of the online course using special shortcodes.

For instance, for the online course "Differential Equations" (Sitak, 2018), the test is considered passed in case of giving 60% of the right answers by the participant. After the test, the participant can look through the number of right answers and time spent on taking it.

An important element while developing an online course is using surveys that enable the teacher to ask participants questions and offer a wide range of possible answers. While creating a survey the teacher describes a certain situation and formulates a question encouraging participants to express their opinion. The final result of the survey is the percentage of the participants who chose one or another response.

During the course "Methods for teaching mathematics to students in technical universities" (Lovianova et al., 2021), "Personal E-learning Environment of the Maths Teacher" (Vlasenko et al., 2019b), "Creative Thinking Through Learning Elementary Maths" (Achkan et al., 2020), etc. surveys are created with the help of the service Google Forms and are used as voting for theme selection as well as for discussion over course materials (figure 6, figure 7).

The choice of Google Forms as a tool for creating surveys is explained by the following characteristics: availability of the created survey for the respondents just after its publication, possibility to edit it, opening for getting answers, and closing after finishing the survey. Furthermore, there is a possibility to integrate forms for surveys on the online course page. In order to show the survey results the service generates automatically the electronic table, there is an option to review respondents' answers in the form of diagrams and graphics with statistical information in high-quality and percentage format.

In the course "Differential equations" (Sitak,

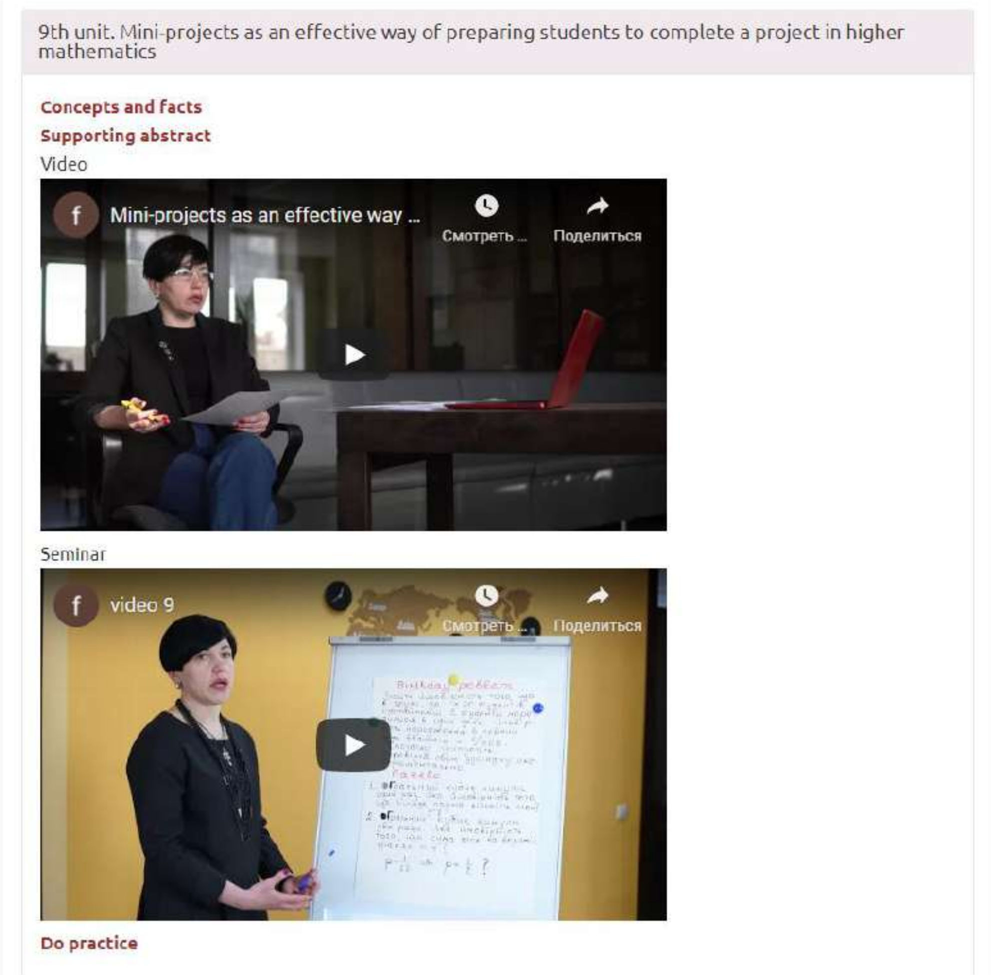

Figure 5: Online course “Project Method in Teaching Higher Mathematics”.

2018) we use the system of tests with the educational aim, not the knowledge control aim. Students can pass tests several times and get instructions for the right answer. Within the course “Methods for Teaching Mathematics to Students in Technical Universities” (Lovianova et al., 2021), we assume to have peer assessment to estimate the performance of training activities. While using such type of evaluation, we followed the recommendations for the development of the criteria table. We took into account the requirements for tasks to be clearly defined and encourage the author (later reviewer) to pay attention to different sides of work. The process of writing a piece of work that corresponds to the requirements and the process of checking such works is useful for participants, as it develops skills of giving constructive criticism including negative.

For every task, the course tutor developed the evaluation criteria with a detailed description of the necessary content on every criterion to get a particular mark. As a tool we offer to use Google Drive services to complete the task; it ensures the possibility to store completed works by implementing shared access to the documents and Google Forms to implement the feedback with participants.

Successful learning of the educational material of the course is completed by getting a certificate. The criteria of getting a certificate are based on criteria-oriented approach that includes the comparison of educational achievements of every participant with planned learning outcomes.

2.6 Feedback Organization

The feedback organization is important both for the course developers and course participants. The necessity to ask questions and receive responses, discuss the issue, express recommendations for the course arises during any education.

The feedback can be organized for every course

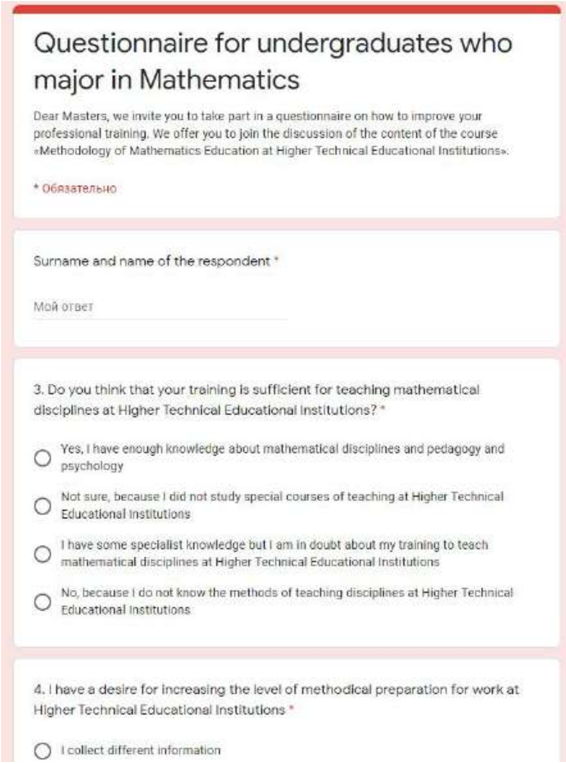

Figure 6: Online course “Methods for teaching mathematics to students in technical universities”.

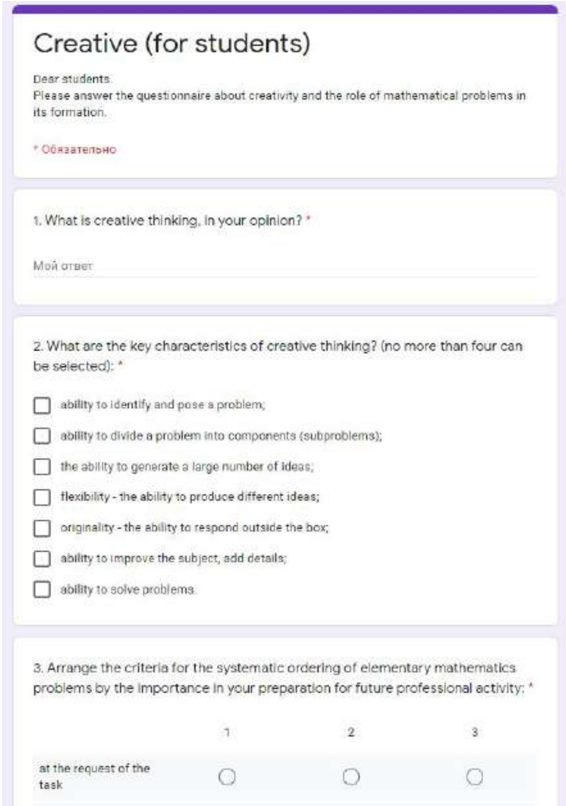

Figure 7: Online course “Creative Thinking Through Learning Elementary Maths”.

separately and the whole online platform. It can be a discussion page, chat, or forum. It is important to organize the prompt course tutors’ notification about new questions and messages. Usually, it is necessary to indicate them in the settings of the corresponding page/forum. Such an option allows reacting promptly to the incoming messages.

For example, during the course “Methods for Teaching Mathematics to Students in Technical Universities” (Lovianova et al., 2021), “Personal E-learning Environment of the Maths Teacher” (Vlasenko et al., 2019b), “Operations Research-Oriented to Cloud Computing in the System CoCalc” (Vlasenko et al., 2020b), the feedback with course participants is organized using thematic forums (figure 8). Participants’ part in the weekly forum gives them a possibility to express their proper opinion using discussion questions that concern the main topics of the course.

Together with the forum use the organization of participants’ communication takes place in asynchronous mode, in other words during a long period. Participants can sign up for the forum to get notifications about new topics and answers on the forum. With the help of the forum, there is a participants’ discussion of their classmates’ works, which is outlined by one of the course tasks. Furthermore, participants can use the forum to share examples of their work and to ask each other questions and the teacher about the studied topics.

The forum implementation on the platform “Higher School Mathematics Teacher” (formathematics.com, 2021) was carried out using the plugin “wpForo” which consists of a set of the main tools for managing the forum. The main advantages of using the plugin are flexible settings of the forum presentation, the creation of a convenient user’s profile, and the possibility to add particular supplements to extend the functionality.

Besides the forum, teamwork with shared documents and emails is used for the organization of feedback during all the courses.

2.7 Editing and Checking

It is important to remember that any material that the course developers give students reflects the scientist’s qualities or the educational institution that is the owner of the corresponding open educational online platform. Thus, all the materials for distance education have to be checked in advance. It is relevant to

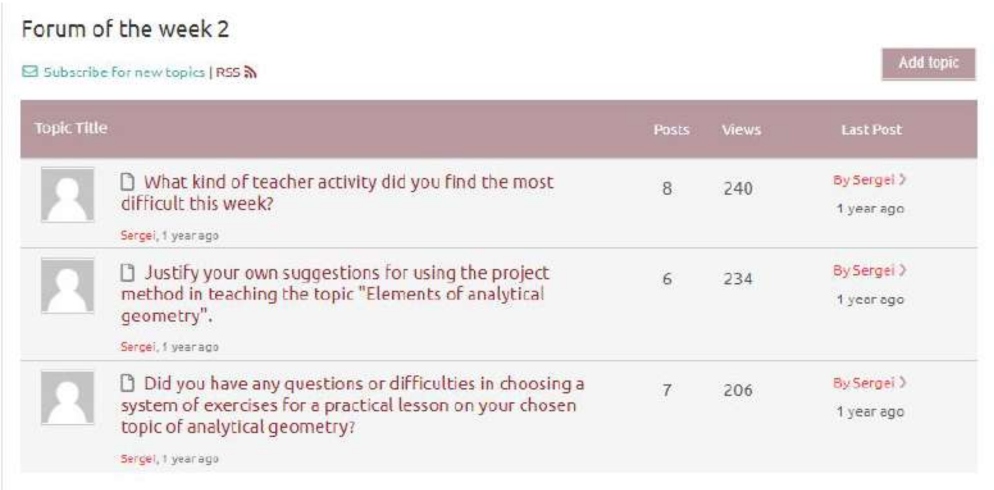

Figure 8: Thematic forum in the course “Methods for Teaching Mathematics to Students in Technical Universities”.

carry out the approbation of the educational course as a pilot project with discussions on the teachers' forum and further consideration of remarks and recommendations. Also, an outside review of educational materials by several users with a different level of training can be used. Reviewers must be developers' colleagues, specialists of the corresponding area, linguists, and non trained specialists.

Before publishing the materials it is necessary to print them and check again. Special attention should be paid to the observance of copyright, it is important to make sure that all the borrowed materials have authors and references.

It is relevant to develop the course not only in the official language but in English too so that it allows increasing the audience of the educational platform significantly.

2.8 Responsiveness

Most users study the course using their phones or tablets. Therefore, it is important to keep this fact in mind in the process of course development. Responsiveness reflects the quality and aesthetics of the system display on mobile devices that have different resolution. To ensure the responsiveness of the course design, it is advisable to use methods of presenting the interface using CSS stylization for individual device resolutions.

It is important to keep in mind that the menu interface and sidebar elements look different on different mobile devices. For a better perception of the course, the developers will need to adapt the size of text, headings and subheadings, links, buttons, image sizes, and other interface elements. Thus, in figures 9-10 we can compare the look of the course page “Personal E-learning Environment of the Maths Teacher” on a desktop computer and a smartphone.

3 RESULTS

To analyze the correspondence level of the content during the course “Methods for Teaching Mathematics to Students in Technical Universities” (Lovianova et al., 2021) to specified recommendations of developing online courses, we held a survey among the participants. Respondents were offered to answer the survey questions using the forum on the platform “Higher School Mathematics Teacher” (formathematics.com, 2021).

68 volunteers who agreed to test the educational materials of the course took part in the survey. Participants' answers allowed evaluating the quality of the developed course and determining minor gaps in the implementation.

We offered them to range the quality of presenting information concerning the structure and semantic content of the online course on a scale from 1 to 5 where 1 is the minimal parameter estimate, 5 is the maximal one. Table 1 provides the survey results.

The ranking results are presented in the form of a histogram (figure 11).

Analyzing the histogram data we concluded that most volunteers have highly evaluated the structure and quality of the developed content of online courses giving 4 or 5 points. In respondents' opinion presenting information concerning the course program, its duration, and frequency of classes were fulfilled most successfully. Among the types of educational content materials in PDF format and video lectures got the

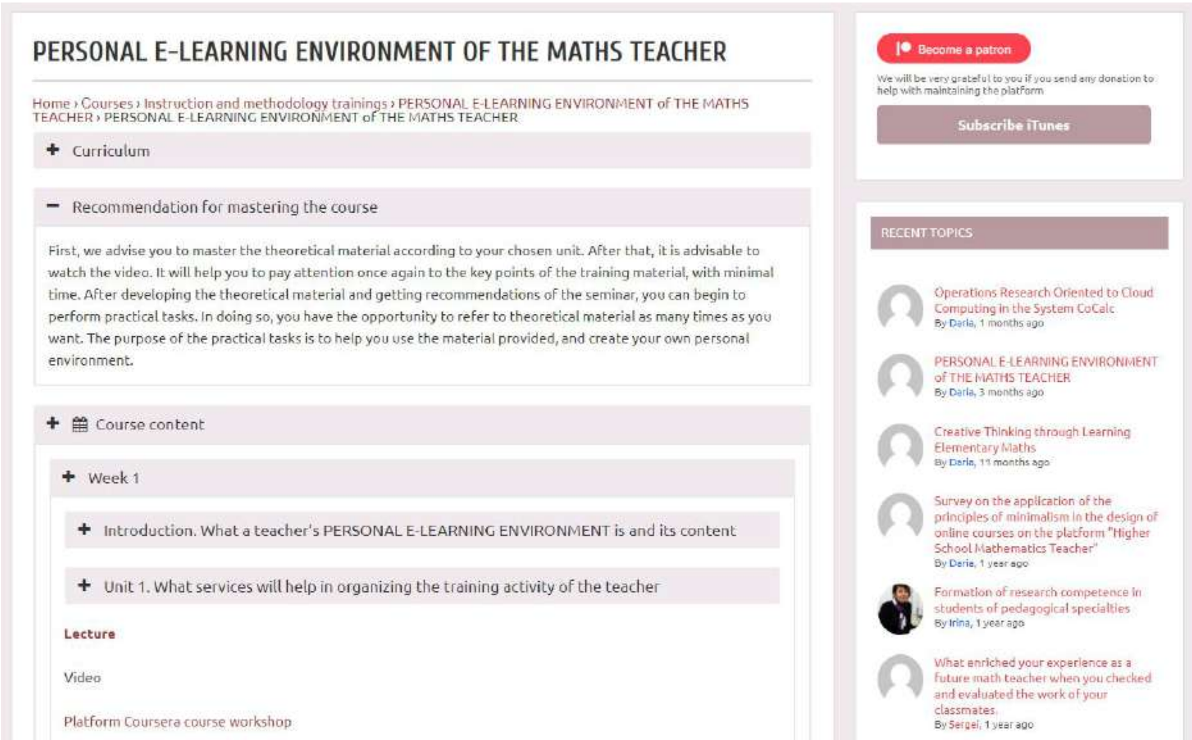

Figure 9: Desktop version of the course "Personal E-learning Environment of the Maths Teacher".

Table 1: Results of testing educational materials of the course "Methods for Teaching Mathematics to Students in Technical Universities".

Questions	Respondents' answers				
	1	2	3	4	5
Accessibility of information presentation concerning the aims and purposes of the course	5	8	10	27	18
Accessibility of information presentation concerning the duration and frequency of the course	3	4	13	23	25
Accessibility of information presentation concerning the target audience of the course	6	3	11	28	20
Accessibility of information presentation concerning the course program	1	6	9	25	27
Convenience of the navigation system during the course	8	9	15	24	12
Quality of presenting educational materials as video lectures	1	4	7	29	27
Quality of presenting educational materials in PDF format	2	6	12	23	25
Quality of tests	3	5	14	26	20
Quality of survey implementation among course participants	4	7	16	21	20
Quality of peer-assessment implementation	4	8	14	20	22
Quality of feedback implementation using the weekly forum	5	8	18	19	18

biggest number of maximal points. So, the presentation of the online course structure and the quality of developed educational materials correspond to the given recommendations.

Moreover, participants were offered to evaluate the general impression from the online course "Methods for Teaching Mathematics to Students in Technical Universities" (Lovianova et al., 2021) (figure 12).

According to the survey results, 68% of respondents believe that the course is developed at a high level, 25% have estimated the course development at a sufficient level and 7% marked that the course requires further development. Among the recommendations given by the respondents concerning the improvement of the online course, we can note the idea of including the final test to evaluate the results of

Figure 10: Mobile version of the course "Personal E-learning Environment of the Maths Teacher".

learning activities and modernization of the navigation system for the course program.

4 DISCUSSION

The analysis of the research by Cuesta (Cuesta, 2010), McGahan et al. (McGahan et al., 2015) and work experience of APass Educational Group, LLC (APass Educational Group, LLC, 2019) developing online courses have confirmed our point of view about the influence of the quality of developing materials for online courses on motivation and success during the course. We agree with the point of view given by Cuesta (Cuesta, 2010) who emphasizes the necessity of constant analysis and evaluation of such parameters as the formation of learning content, interaction among course participants. We support the conclusions given by McGahan et al. (McGahan et al., 2015) about the importance of developing methodical requirements for the content of online courses as the main tool of its quality evaluation. The recommendations provided by the APass Educational Group, LLC (APass Educational Group, LLC, 2019) are very important for our research; they offer to provide the efficiency of the educational aim of the course using the following means: clear purpose presentation; correspondence of the aim to the students' expectations; direct responsibility between educational aims and students' actions during the course and their evaluation; learning materials selection and technologies that correspond to the educational aims, student's motivation and support of their progress; content accessibility for all the students.

We got acquainted with the accomplishments of Scagnoli et al. (Scagnoli et al., 2019), Morrison (Morrison, 2017), Puzziferro and Shelton (Puzziferro and Shelton, 2019) when we started developing video lectures. These works are dedicated to the research of students' opinions on the use of video lectures in online classes. So, during the development of video lectures, we were focused on the scientists' recommendations. These recommendations were the following: to consider students' needs; to plan thoroughly and integrate into a balanced way video lectures with other course materials; to use multimodal information delivery; to create a sense of cooperation with the content through students' control over the media and teachers' presence.

The acquaintance with students' evaluation via Camtasia (Quora, 2019) as one of the most available programs of editing and creating video has proved the relevance of the choice of this program for presenting course content. Screen recording with necessary effects helped us to create a high-quality new presentation and documents in PDF format. The involvement of such a type of material was approved by the forum participants. During the course presentation and every week, we encourage students to take an active part in forums. This approach corresponds to the conclusions given by Martín-Blas and Serrano-Fernández (Martín-Blas and Serrano-Fernández, 2009), who prove that participants who take an active part in forum discussions tend to get higher marks and show a higher level of learning edu-

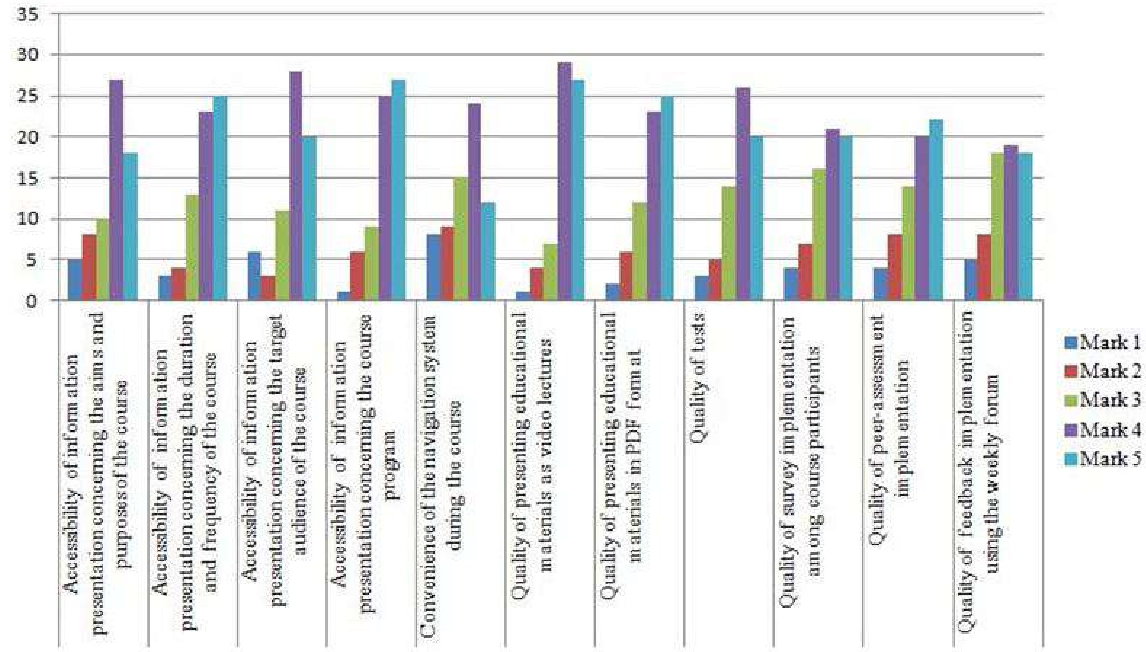

Figure 11: Results of testing educational materials of the course "Methods for Teaching Mathematics to Students in Technical Universities".

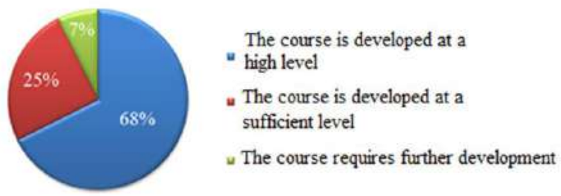

Figure 12: The general impression from the online course "Methods for Teaching Mathematics to Students in Technical Universities".

cational material in comparison to those who did not use the forum.

5 CONCLUSIONS

The relevance of the matter to develop methodical recommendations for the structure and content of online courses arises from the fact that the quality of education using online courses depends on the quality of content development. Educational materials have to be interesting, correspond to students' expectations, and encourage motivation during the course. The content development requires thorough planning and balanced integration with other course materials. Testing during the course should have both controlling and educational functions. The creation of course content should be accompanied by the evaluation of students who help to assess the quality of the developed educational materials and detect gaps.

Based on the analysis of current recommendations regarding the development of online courses, as well as considering the results of students' and teachers' surveys we have described the methodical recommendations for the structure and content of online courses. The course is based on weekly planning, the test subsystem is implemented under extended functionality, and abilities to organize feedback are integrated. While planning online courses it is necessary to plan properly and organize feedback with course participants. The feedback allows detecting both positive aspects and gaps, drawbacks that were detected during project planning and implementation.

The possible way of implementing feedback is the creation of several thematic forums where information exchange among the participants is possible.

The results enable to define several directions for further research, among which the implementation of online resource usability.

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Content Analysis of Course Books and Online Courses for Teaching English for Specific Purposes for IT Professionals

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Keywords: IT Professionals, Foreign Languages, Course Books, Online Courses.

Abstract: The paper deals with the issue of English language training for IT professionals at Ukrainian universities. Understanding the importance of studying foreign languages has been confirmed by a number of normative documents. Peculiarities of professional training of IT specialists at higher education institutions with the focus on foreign language training are considered. Pedagogical conditions for formation of the communicative competence of IT professionals are analysed. The content analysis of existing English course books, textbooks and online courses for IT professionals has been conducted to find out the content of foreign language training. It is stated that English language teaching aids in information technology, computer engineering, computing and software engineering can be used in the learning process, however, their use requires thorough refinement and modification. The series of guides, manuals and online courses for teaching English for professional purposes are presented.

1 INTRODUCTION

Education institutions have always been the space for implementation of new ideas, venues of progressive events and places for changes and new discoveries. It comes as no surprise universities around the world have become main promoters of sustainable development ideas and goals. Education for Sustainable Development (ESD) emphasizes the necessity of "equipping students with the knowledge and understanding, skills and attributes needed to work and live in a way that safeguards environmental, social and economic wellbeing, both in the present and for future generations" (QAA and Advance HE, 2021).

Modern realms prove that much more attention is given to environmental and economic spheres of life, while the socio-cultural area remains untouchable (Zygmunt, 2016). Languages, communication, human interaction are essential parts of human lives, and they cannot be disregarded in this respect. In addition, the question arises of why languages are missing from the Sustainable Development Goals (SDGs), as these are precisely languages that can deliver the SDGs correctly and accessibly. Moreover, "99 percent of negotiations on the SDGs were done in English, and 100 percent of negotiation outcomes were written in English" (Tesseur, 2017).

Nowadays, foreign language training is an integral component of all stages of secondary and higher education, and this process becomes even more significant under the conditions of ESD. The high level of the language proficiency, certainly, fosters career promotion, the increase of the intellectual and cultural levels of specialists, and easy adaptation of them in a foreign language environment. Employer requirements for engineering and technical knowledge, skills and competences are constantly being complicated. This happens due to the accelerated evolution of technical skills, the emergence of new engineering professions and the penetration of technology in all the areas of human lives. This fact also imposes an imprint on the foreign language level requirements. The significance of the sufficient foreign language level for IT professionals is even more crucial, as they often

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work in international companies or teams, therefore the foreign language knowledge impacts on the result of their individual or joint work.

The significance of learning foreign languages for Ukrainian students has been recognized by all the participants of the educational process. Its importance has been confirmed by a number of normative guidelines. The recommendation letter of the Ministry of Education and Science of Ukraine "On the organization of studying humanities" No 1/9-120 dated March 11, 2015 states that "it is necessary to create conditions for the study of English as a language of international academic communication, in order to reach B2 level in accordance with The Common European Framework of Reference for Languages" (MON, 2012). Knowledge of foreign languages is of crucial importance for IT professionals, and the letter of the Ministry of Education of Ukraine "On improving the quality of training for the IT industry" (MON, 2015) indicates the need to review the content of regulatory disciplines, foreign language disciplines, economic and jurisprudence disciplines taught in the training of IT professionals in accordance with modern information technology.

The higher education standards of Ukraine for the field of knowledge 12 "Information technology" field of knowledge cover a complication of requirements for obtaining competences, including foreign language competence from the first to the second level of higher education. Thus, for a bachelor's level, the outcome of learning foreign languages is the ability to use a foreign language in written and oral communication (MON, 2018). For the master's level, the formulation of learning outcomes is expanded: IT professionals have to be able to use foreign languages in their professional activities (MON, 2020).

The objective of the paper is to carry out the analysis of existing course books, textbooks and online courses for IT professionals in the context of their training at higher education institutions.

2 PECULIARITIES OF IT PROFESSIONAL TRAINING AT HIGHER EDUCATION INSTITUTIONS

The analysis of scientific publications has shown that peculiarities of professional training of IT specialists have been studied by Dubinina (Dubinina, 2016), Korotun et al. (Korotun et al., 2020), Striuk (Striuk, 2012), Sydorov et al. (Sydorov et al., 2010), Tereminko (Tereminko, 2017) and others. Chemerys et al. (Chemerys et al., 2019), Kruhlyk and Osadchyi (Kruhlyk and Osadchyi, 2019), Semerikov et al. (Semerikov et al., 2020), Varava et al. (Varava et al., 2021) have been engaged in the analysis of professional qualities of software engineers. Certain aspects of communicative training of IT specialists have been investigated by Babii (Babii, 2012), Bulakhova (Bulakhova, 2007), Chirva (Chirva, 2008), Kirilenko (Kirilenko, 2016), Strilets (Strilets, 2010) and other researchers.

Striuk (Striuk, 2012) notes that a software engineering specialist "must be familiar with computer hardware, system infrastructure, methods, tools and technologies for developing software; be able to design, develop and maintain software". The scientist emphasizes that in the field of information technology big and small projects that require skilled management are implemented, and therefore students of the software engineering speciality learn to solve the problems of justification, planning, ensuring economic efficiency, quality and timely implementation of software projects working in teams. In the context of globalization, the development of software using the Internet is widespread, so students learn the appropriate technologies. The author focuses on learning professional disciplines, but he does not consider the importance of foreign language training of IT specialists.

Tereminko (Tereminko, 2017), studying problems of communicative competence improvement for competitive IT professionals emphasizes that they are largely related to the low adaptability of the education system and, as a result, university graduates to the dynamic changes in the IT industry. Therefore, one of the requirements for vocational training is the formation of student readiness for professional mobility as an integrative quality of the individual, which is the ability to actualize their potential opportunities for adaptation to rapid changes in the professional sphere, formed on the basis of awareness of the need for the specified quality in their successful professional realization and their high level of the professional competence, their desire to develop professionally and to succeed. The researcher notes that professional disciplines have a great potential for forming readiness for professional mobility, and this process can be successfully supplemented by such disciplines of other cycles as foreign languages, in particular, English for professional purposes, psychology of business communication, and ethics and aesthetics.

An important contribution to the theory of vocational training of future specialists in software engineering has been made by Dubinina (Dubinina, 2016), who has developed the job description for a specialist in the field of software engineering. She has divided qualities that ensure the success of such a professional into personal qualities, interests, aptitude and abilities. The researcher has identified the professional tasks that such a specialist should solve, according to the types of professional activity. In particular, she identified the following professional tasks in the process of analytical activities of software engineering professionals: collecting and analyzing customer requirements for software; formalization of the subject area of the software project by the results of the terms of reference and rapid examination; assisting the customer in evaluating and selecting software options; participation in preparation of the commercial offer to the customer, preparation of the presentation and approval of the package of contract documents. The tasks of designing activities are the following ones: participation in the design of software components to the extent sufficient to design them within the task; creation of software components (coding, debugging, unit and integration testing); performing measurements and refactoring code according to plan; participation in the integration of software components; development of test environment, creation of test scenarios; development and execution of sketch, technical and working project documentation.

The technological activity implies the ability to perform the following professional tasks: development and application of automated design, development, testing and maintenance of software; development and application of methods and tools of management of engineering activities and processes of software life cycle; use of standard control methods, evaluation and quality assurance of software; ensuring compliance of the developed software products and technical documentation with Ukrainian and international standards, specifications, departmental normative documents and standards of the enterprise; participation in the research related to the subject of professional activities in accordance with approved objectives and techniques. Production activities are the following: interaction with customers in the process of implementation of the software project; participation in software development processes; participation in the creation of technical documentation on the results of the works; participation in the preparation of technical documentation and established reporting in the approved forms; planning and organizing your own work; planning and coordination of software setup and maintenance work; drawing up a technical task for software development; organization of work of small teams of program project executors; participation in the feasibility study of program projects; commissioning of the software; preventive and corrective maintenance of the software product during operation; training and consulting of users on work with the software system (Dubinina, 2016). However, the researcher has not emphasized that most of these professional tasks will be difficult to accomplish without having the rather developed communicative competence, including the foreign language communicative competence.

Sydorov et al. (Sydorov et al., 2010) on the example of the Professional Practice of Software Engineering discipline puts forward the following requirements for the organization of professional training of specialists in software engineering. First, students should be prepared to adapt to specific work that is as close as possible to their real work, and teachers must be practically and professionally trained (in terms of software development). Therefore, it is advisable to conduct training within a software development company; involve professional developers in teaching disciplines; to organize practical classes according to modern requirements. Second, students should integrate their own knowledge and skills and direct the results to software development, and teachers, using appropriate teaching materials, should simplify this integration. In their study, the authors have not focused on communicative training for future software engineering professionals.

This deficiency of research in the national scientific thought has been eliminated by some pedagogical studies. In particular, Kirilenko (Kirilenko, 2016), on the basis of the analysis of international requirements for software engineering teaching (Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering ACM / IEEE), notes that the listed abilities include not only highly specialized engineering knowledge, skills and qualities, but also “skills in effective reasoning, ability to work in a multidisciplinary team, understanding of professional and ethical responsibility for making engineering decisions, ability to analyze and criticize decisions, people management skills and understanding of the importance of lifelong learning”.

Babii (Babii, 2012) considers the proficiency in professional communication to be important for software engineers, because “it is necessary to involve the whole team of specialists for development of modern software, which requires knowledge of teamwork skills, knowledge of psychology fundamentals, group dynamics and communication, which is a guarantee of achievement of professionally significant results”. The researcher identifies two groups of competences that she considers the basis of the cognitive component of the readiness for professional communication of future software engineers: instrumental and specialized-professional competences. The first group, according to the researcher, includes the ability to write and communicate in the native language (the ability to use the language correctly depending on the scope and purpose of communication, to make business papers); knowledge of another language (practical knowledge of a foreign language in terms of subjects due to professional needs); the use of oral language within the framework of domestic, social and political and professional subjects; the ability to translate general economic texts from a foreign language into a native language); research skills (ability to apply research skills in specialized disciplines); the ability to create technical documentation for a software project. The second group includes the ability to conduct business negotiations with business partners and the ability to reasonably convince colleagues of the correctness of the proposed solution, the ability to convey their position to others.

Chirva (Chirva, 2008) believes that in today's realities there is a growing need for future software engineers to develop the skills and abilities of dialogic speech itself, which is conditioned by economic reforms being carried out in Ukraine at the present stage (contacts of specialists of technical profile with foreign partners when creating joint ventures, work with imported equipment, etc.). The scientist assures that students must be able to communicate effectively in English. According to the requirements of the English for Specific Purposes (ESP) program, a prospective professional should be able to respond to basic ideas and identify relevant important information during detailed discussions, discussions, formal talks, lectures, related conversations with training and profession. The high level of foreign language communicative competence of future software engineers is a guarantee of improvement of their professional level, enrichment of knowledge in a speciality and successful professional activity.

According to Bulakhova (Bulakhova, 2007), in their professional activity, software engineers "must actively cooperate with foreign partners, representatives of different cultures and levels of professional competence; be aware of the latest scientific and technological developments in their manufacturing field, using foreign sources of information. The success of their professional activity depends on communication skills and knowledge of a foreign language". On this basis, the author insists that for the effective acquiring mastery of a foreign language, the following requirements must be taken into account: the orientation of the teaching system to the formation of students' systemic vision of the subjects studied; flexibility and variability of content, taking into account the needs of education and the individual; humanization of technical education; orientation on mastering new information technologies; ensuring the methodological, specialized scientific and professional competence of the specialist. While studying, students should be aware of the substantive and procedural part of their future professional activity.

The same opinion is emphasized by Strilets (Strilets, 2010), pointing out that modern society needs specialists in programming who have the system thinking, are able to generate ideas, to be aware of the responsibility for the consequences of the decisions made, quickly adapt to new conditions, find ways to overcome problem situations; are able to navigate the information space, quickly find and process the necessary information, use electronic communications, a variety of software when solving production tasks. In the professional field, software engineers mainly use a foreign language when searching for and processing information from Internet resources, programming, and communicating with foreign partners through electronic communications. Therefore, the process of foreign language training of future specialists in software engineering is important. The author highlights the following communicative skills of future programmers: reading in various modes (search, study) computer messages, system help programs, specifications, instructions, articles in electronic professional publications, materials of professional community forums, online workshops; participation in dialogue / discussion-dialogue, communicating both directly and through electronic means; production of a monologue presentation; writing instructions, reports, forum posts. Their formation is proposed to be implemented in the process of the project methodology of teaching English to future programmers using a distance course.

The high level of foreign language communication competence in the professional activity and professional environment is considered to be a necessary component of the characteristic of a modern IT specialist. According to the research of Viakh (Viakh, 2013), an IT specialist is considered competent if he or she successfully completes the following tasks in a foreign language: 1) finds the necessary information in a foreign language text without assistance; 2) understands technical instructions, articles, educational texts in foreign language from popular and promising areas of the IT industry without assistance; 3) uses tools that accelerate and refine the comprehension of a foreign language text (various electronic dictionaries, glossaries); 4) constantly improves foreign language skills; 5) makes a structured written presentation in a foreign language; 6) conducts competent correspondence in a foreign language with the customer, employer through messenger programs, e-mail; 7) states the facts in a foreign language clearly orally and in writing; 8) competently and objectively verbally presents in a foreign language themselves, their skills, experience, goals, aspirations; 9) draws up an effective competent resume in a foreign language, is able to sell their skills; 10) makes oral presentation in a foreign language; 11) formulates and communicates ideas, submits proposals both verbally and in writing in a foreign language; 12) provides technical guidance in a foreign language, both orally and in writing; 13) advises clients and colleagues in a foreign language; 14) explains information to different audiences in a foreign language; 15) clarifies information for themselves in a foreign language; 16) effectively agrees with the customer in a foreign language on: a) the subject area; b) product requirements; c) payment; d) terms; e) support; 17) distinguishes the main from the heard broadcast in a foreign language; 18) understands oral language directly, via telephone or messenger programs; 19) understands and takes into account the concept of time in different countries; 20) knows domestic and international business etiquette; 21) possesses sociocultural knowledge of other countries (holidays, weekends, greetings, taboo topics, etc.) and takes them into account when communicating; 22) is engaged in professional self-education, reading professional literature, blogs, forums in a foreign language; 23) participates in projects, project planning, project management and evaluation of projects using a foreign language. Thus, the researcher concludes that foreign language communication competence is a decisive factor in employment and career development in the IT field.

3 PEDAGOGICAL CONDITIONS FOR THE FORMATION OF THE COMMUNICATIVE COMPETENCE OF IT PROFESSIONALS

The conditions under which communicative competence of modern professionals is formed have been investigated (Kazhan et al., 2020; Kraievska, 2014; Novgorodtseva, 2008; Yefimova, 2014; Yermakova, 2015), in particular, communicative competence formation of future IT specialists has been studied by Bulakhova (Bulakhova, 2007), Viakh (Viakh, 2013), Chirva (Chirva, 2008) and others.

Yefimova (Yefimova, 2014) determines the following pedagogical conditions, the observance of which ensures that students achieve a higher level of communication competence formation: 1) development of teacher empathy; 2) development of communication skills; 3) individualization of training (introduction of academic counseling (tutoring)).

Kraievska (Kraievska, 2014) lists the pedagogical conditions for the development of communicative competence of future agrarian managers and includes there the need for the gradual formation of motivation for the communicative activity in the process of their professional training. The other pedagogical condition is the development of the content of communicative training of future agrarian managers on the basis of systematic and integrative approaches. The implementation of these conditions is the basis for applying the methodology of complex formation of structural components of communicative competence using information and communication technology, which is advanced by the researcher as the third pedagogical condition.

Novgorodtseva (Novgorodtseva, 2008) determines that the formation of the professional communicative competence of future engineers at higher education institutions will be effective under the following organizational and pedagogical conditions: 1) professional training orientation to the professional-communication competence of future engineers; 2) development of the author's training courses aimed at the formation of the professional and communicative competence; 3) development and use of the algorithm of formation of the professional communicative competence of future engineers, containing three interrelated stages: preparatory (knowledge), basic (activity), and final (reflective) ones; 4) use of pedagogical technologies, a complex of didactic means in the process of professional training of future engineers; 5) development of a system of criteria for assessing the levels of the professional communicative competence of a future engineer.

Viakh (Viakh, 2013) has identified the following conditions for the formation of foreign-language communicative competence of future specialists in the field of information technology: systematic learning the industry-specific content in a foreign language, modeling the professional activities of future specialists in the field of information technology by means of a foreign language, implementation of the principles of mixed learning materials in teaching materials. The researcher has paid particular attention to the use of information and communication technologies in the process of forming foreign communication skills of future specialists in the field of information technologies, namely applying instant messaging programs Skype, Google Talk, ICQ, QIP, Miranda, professional electronic journals (Tech Crunch, Computer, EEEM), blogs (A + Computer Science Blog, Pastacode computer science blog, etc.) and country sites.

Exploring the methodological approaches to teaching English dialogues of future software engineers, Chirva (Chirva, 2008) believes that creating a favorable environment with the use of level differentiation is important for training each student according to the level of their academic achievements and abilities. In her opinion, it is advisable to introduce a computer program for the organization of differentiated teaching of English dialogues of future software engineers in a technical institution of higher education, which is justified by the need to improve the quality of foreign language training of future software engineers at all levels; the need to obtain the desired result is to increase students' skills and competences. Instead, the researcher Ya. Bulakhova identifies meaningful and procedural pedagogical conditions for teaching software engineers, which take into account the connection between social contract for engineering training, contradictions at national higher education institutions and the specifics of teaching a foreign language at a university (Bulakhova, 2007).

Based on the research of Yermakova (Yermakova, 2015), we follow this understanding of the pedagogical condition: a circumstance on which the performance of professional activity depends and in which different results are possible.

The analysis of modern requirements for the organization of professional training of software engineers in Ukraine and abroad, the generalization of the experience of forming communicative competence of IT specialists allow us to define the following organizational and pedagogical conditions for the formation of communicative competence of software engineering specialists at institutions of higher education (Symonenko, 2019):

- complementing the content of curricula and educational-methodological complexes of foreign language disciplines with exercises, activities, texts and patterns of effective professional communication;
- application of interactive forms of training of selected professional disciplines, taking into account the specifics of professional activities of software engineers in the implementation of dominant methods (project method, method of teaching in collaboration (small groups), brainstorming, case method);
- use of synchronous and asynchronous communication tools, special Internet resources, social online networks and virtual communities in the teaching of foreign language and vocational disciplines in foreign language in classroom and extracurricular work;
- the efficiency of the process of forming techniques and methods of interpersonal interaction, which form the basis of professional communication of software engineers is ensured by involving students in communication activities, which maximally simulates the process of professional interaction and creates the conditions for professionally and personally-oriented professionals.

4 CONTENT ANALYSIS OF COURSE BOOKS, TEXTBOOKS AND ONLINE COURSES FOR TEACHING ENGLISH FOR IT PROFESSIONALS

The curricula of some specialities of the field of knowledge 12 "Information technology" of higher education institutions of Ukraine regarding the availability and scope of foreign language disciplines have been analysed. The range of foreign language disciplines is as follows: foreign language, foreign language for specific purposes, profound foreign language, business foreign language, foreign language for scientists.

Foreign languages at Ukrainian higher education institutions are the part of the humanities cycle. The foreign language for specific purposes discipline is obligatory as it is stated in the higher education standard of Ukraine and is usually taught in the first and second years. Other language disciplines can be selective by students.

Learning a foreign language for professional purposes during the first and second years can be a challenge both for language instructors and students, because students lack knowledge in their speciality, since professional disciplines are taught to senior students. Moreover, as the results of the national entrance exam and university foreign language entrance tests show, the vast majority of first-year students majoring in engineering, technology, agricultural science have a very low level of the foreign language proficiency (A1), and the progress to the higher level of an independent user (B2) becomes a very complicated process.

In order to supplement the content of curricula and educational and methodological complexes of foreign language disciplines with exercises, activities, texts and patterns of effective professional communication we have analyzed the contents of course books and textbooks for teaching English at higher education institutions, and in particular for specialists in computer science, information technology, Internet technology and software engineering. The similar research has been carried out by Jodoin and Singer (Jodoin and Singer, 2020) to analyze the contents of English textbooks to find out whether this material is used effectively to train university students in terms of SDG.

To study the content of teaching foreign languages for professional purposes for IT professionals, we have analysed existing English language course books, textbooks and distance courses for information technology specialists, computer engineering, software engineering and computer science students. The following aspects have been taken into account: the presence of tasks and activities for the development of all four language skills (reading, speaking, listening, writing); grammar and vocabulary focus; the professional orientation of the content; the presence of job-related situations; the availability of additional materials and resources for self-study.

The ESP textbook by Goltsova (Goltsova, 2002) "The English Language Guide for PC Users and Programmers" provides educational materials for teaching English to technical students and students studying the English language, computer science and advanced computer technology. Each of the 25 lessons has the sections: Grammar and Vocabulary and Reading. The first section contains materials for learning English grammar in the traditional format. The second section contains a list of words for one or more texts and general exercises for vocabulary training on the main topics of computer science and programming. The benefits of the manual are its original structure and the use of basic special vocabulary, but the disadvantages are the moral obsolescence of the texts, the absence of listening activities and the lack of focus on developing communication skills, including the lack of dialogue practicing and job-related phrases.

The English for Internet Technology Professionals guide (Vichugov and Krasnova, 2012) is aimed at developing language skills and skills in the language use in the field of professional communication. It contains authentic texts, tasks for listening and speaking, and vocabulary on seven topics: history of the Internet, Internet privacy, Internet services, online payment systems, E-mail service, personal web page, Internet security. The benefits of this guide include the availability of exercises and tasks for practicing communication skills (discussions, dialogues, reflections), but the vocabulary is limited to only one field – Internet technologies, which will not obviously be enough for IT specialists to communicate.

The Computer Engineering course book (Bondarev et al., 2014) presents the system of authentic texts for vocabulary acquisition on different IT-related topics: computer and computing, software, virtual reality, computer security and others and sets of exercises and activities. The course book comprises 10 units which have the similar structure, each unit includes lead-in, pronunciation, word study, word building, grammar, reading, writing and speaking tasks. The Get Real section provides links to up-to-date Internet sources which can be helpful for speaking and writing activity performance. Speaking tasks are predominantly aimed at pair and group work, role plays and deal with the job-related situations or student theoretical knowledge in the field of information technology or their practical experience.

The English for Computer Science Students textbook (Smirnova and Yudelson, 2017) is offered for the analytical or home reading of vocationally-oriented texts, vocabulary boosting, English-speaking skills in oral and written forms. It consists of 9 lessons, each of which in addition to the industry-specific texts contains a number of interesting exercises aimed at mastering scientific and technical vocabulary, namely terms, abbreviations, acronyms, etc. The guide is aimed at students, graduate students and anyone with a basic knowledge of English and interested in current issues related to the emergence, development and future of computers in the global computerization of society.

The advantages of the Ukrainian and Russian coursebooks analysed above are their original structure, the use of authentic texts, the presence of basic professional vocabulary and activities for its boosting. These teaching aids and these books have not tasks for the development of listening skills, not all course books focus on activities for enhancing communication, certain examples of samples of dialogues cannot be found, tasks for problem-solving are absent.

The Oxford English for Information Technology course book (Glendinning and McEwan, 2006) is intended for students majoring in information technology and computer engineering, for professionals already working in the field and who wish to improve and expand their English language skills in the context of information and communication technologies. Compared to the first edition of 2003 (Glendinning and McEwan, 2003), the 2006 edition takes into account the latest developments in this fast-growing sector, as reflected in the content update. New materials reflect changes in areas such as specifications, new technologies and practices. The student's book consists of 25 lessons covering a wide range of IT topics. The materials of the course book include authentic texts and visuals taken from textbooks, newspapers, popular computer magazines, online newsgroups, webpages, manuals and advertisements. Each lesson contains tasks for language skills development, and every fifth lesson focuses on developing listening skills through authentic interviews with IT professionals. For students who already have rather good knowledge of English vocabulary in IT, there are additional special reading texts. The teacher's guide includes a theoretical introduction to the topic of each lesson for non-IT teachers to better achieve the learning goals. However, the manual does not sufficiently focus on software development issues, communication with the team members and customers, which is an important topic for training software engineering professionals.

Among the analyzed publications the Express Publishing editions of Career Paths series are of special interest. The series is intended for professionals who want to improve their English language skills in the work environment. They include a special vocabulary and texts, step-by-step tutorials that immerse learners into four major language aspects: reading, listening, speaking and writing. The course book contains three books in three difficulty levels (A1, A2 and B1) and offers over 400 lexical terms and phrases. Each lesson includes a test to check reading comprehension, vocabulary and listening skills, and help students develop their writing and oral communication skills. The Career Paths: Information Technology Guide (Evans et al., 2011c) covers topics related to computer design: components, hardware, software, Internet security, web design, and the future of the IT industry. The Career Paths: Computing Guide (Evans et al., 2011a) is intended for professionals who want to improve their English communication skills in the computer industry. It includes topics related to computer hardware, general applications, operating systems, online communications, and cloud computing.

The Career Paths: Software Engineering Guide (Evans et al., 2011b) discusses topics in software development, software testing, user interface, modeling, and career options in software engineering. An important structural element of this publication is dialogues specific to the profession and the numerous job-related texts in the field of software engineering. Therefore, this guide combines specialized vocabulary and professional context to form necessary communication skills for a career. The textbook contains three books of different levels: Elementary (Book 1), Pre-intermediate (Book 2), and Intermediate (Book 3). The books contain 15 lessons of different topics, each topic focuses on a specific reading context and serves to form a certain communicative skill. For example, the second lesson on Types of Computers contains the text for reading in the form of a magazine article, which involves new vocabulary acquisition (computer, computing cluster, desktop, embedded computer, laptop, notebook, PC, server, tablet, workstation) and aimed at forming ability to make plans. However, despite the elaborate structure, professionally oriented exercises, texts and dialogues, the disadvantage of the course book is that there is no consistency between the topic of the lesson, the vocabulary words to learn and the skills formed during the lesson.

The Career Paths book series offers applications which can be available for self-study on personal computers and portable devices. Applications provide all the activities present in the original books in the user-friendly format, all the exercises from the main books have been adapted as interactive ones. Supplementary activities which are absent in the course books include video comprehension on the topics of units. Applications allow to evaluate and trace easily the student's progress automatically without an English instructor. The glossary included in the application allows students to check the word meaning in the context and to listen to the audio pronunciation of the word.

The English for Information Technology 1, 2 (Hill, 2012) books are intended for IT students and company employees. The course books cover topics in current IT developments, including working in IT, IT systems, data communication, administration, interactions, development and IT solutions. The materials of the course book include authentic texts and visuals taken from up-to-date sources. Each lesson contains tasks for language skills development, and every last section of the unit focuses on job-related situations (business matters). Numerous activities including vocabulary acquisition, pronunciation training, speaking, and listening are designed to work in pairs and to get feedback from partners in different forms. The course also provides online teacher support, CD-ROMs with audio files and interactive glossaries in US English and British English for students.

The Professional English in Use: ICT manual (Esteras and Fabre, 2007) covers a wide range of topics in information technology, including personal computers, word processing, financial software and databases, multimedia applications, e-mail, web design and Internet security. The course book which includes 40 units is designed as a reference and practical manual for independent work. The structure of each unit is similar: the unit includes a text for reading, exercises for reading comprehension and new vocabulary acquisition checking, and writing tasks or links to online exercises. The manual can be used as a supplementary aid to the main course book of professional English.

The Information Technology Workshop (Demetriades, 2003) course book covers numerous topics in IT, including Internet, multimedia, programming, careers in IT etc. The course book includes 28 units which have the similar structure: each unit includes a pre-reading task, a text for reading, reading comprehension exercises, a vocabulary exercise, a task for writing and a 'get real' task which gives a possibility to implement new knowledge in real-life or job-related situations. The course book can be used as a supplementary book to the main course book of professional English.

The Infotech: English for Computer Users course book is intended for students who need to improve their professional English skills. Compared to previous editions, the fourth edition (Esteras, 2008) takes into account the latest updates in information technology and includes significant content revision. The course book comprises 8 modules covering computer devices, software, Internet, computers jobs and future of computers. Every unit includes reading, listening, speaking and writing activities, a language work section with exercises. The main course book can be supplemented with an interactive workbook which contains different activities according to the content of units.

The English for ICT Studies in Higher Education Studies course book (Fitzgerald, 2011) differs significantly from the English course books for IT professionals as it is designed for learning the academic language. It is intended for students who are going to study ICT as an academic discipline or as a major at a higher educational establishment, it covers a wide range of topics: ICT in the workplace, ICT in education, contentious issues in computing etc. The activities of 12 units of the course book are primarily aimed at development of student skills necessary for lecture listening and class participating and include reading, listening, vocabulary boosting exercises and writing and speaking assignments. Vocabulary banks and skills bank presented in the course book help students to review the contents of each lesson.

The results of the conducted analysis are presented in table 1.

Top world universities and companies offer numerous online courses on foreign languages. English courses for IT professionals can also be found in the web, including courses on popular platforms. The popular Udemy platform offers the English for IT professionals course (Udemy, 2021) which is intended for students majoring in IT or people who already work in the IT industry. The main aim of the course is specific vocabulary and grammar acquisition. The course covers profession-related topics such as IT jobs, equipment and work environment, programming and others. As course authors state, "carefully chosen grammar topics … help … speak more confident at work and about work". The course includes video lectures, tasks for checking comprehension, and term wordlists. The distinctive features of the course are the following: the content of the course is quite up-to-date, the grammar rules are explained in the profession-related context, all the video lectures have English subtitles for better understanding, all the tasks are closely related to the lectures. The significant disadvantage of the course is rather limited communication with learners and teachers, sharing their opinions with other students in the course, only one task presupposes making comments on the topic.

The English for information technology online course (www.english4it.com, 2021) covers IT careers, computer ethics, freelancing and other comprehensive topics concerning the information technology industry. The course consists of 28 units of the similar structure comprising reading and listening comprehension exercises, speaking and writing tasks, spelling and recognition wordlists which present main terms in the context and allow to listen to word pronunciation. Basic activities are computer-graded, while advanced activities (speaking and writing) are teacher-graded. The student progress can be traced in the grade report which presents grades, units completed, time tracking.

The content analysis of course books and textbooks for English learning at higher education institutions, in particular, for professionals in the field of information technology and software engineering, has shown the abstract nature of the used case studies and low applied importance of the chosen topics of educational interaction. Therefore, as a result of the analysis of English language teaching aids in information technology, computer engineering, computing and software engineering, we can conclude that some of them can be used in the learning process, however, their use requires thorough refinement and modification.

In order to improve the content of English language learning to form communicative competence of software engineering specialists at higher education institutions, taking into account all the advantages and disadvantages of existing teaching aids we have developed and implemented the following teaching aids(TSATU, 2021b):

Table 1: Analysis of course books and textbooks for teaching English for IT professionals.

Course Book	**CEF level**	**Vocabulary**	**Grammar**	**Reading**	**Listening**	**Speaking**	**Writing**	**Resources**
English Language Guide for PC Users and Programmers	B1-B2	+	+	+				
English for Internet Technology Professionals	B1-B2	+	+	+		+	+	
English for Computer Science Students	B1-B2	+	+	+		+	+	
Computer Engineering	B1-B2	+	+	+		+	+	
Oxford English for Information Technology	B2-C1	+	+	+	+	+	+	
Career Paths: Information Technology	A1-B1	+	+	+	+	+	+	Application
Career Paths: Computing	A1-B1	+	+	+	+	+	+	Application
Career Paths: Software Engineering	A1-B1	+	+	+	+	+	+	Application
English for Information Technology	A1-A2, A2-B1	+	+	+	+	+	+	Interactive glossary
Professional English in Use: ICT	B1-C1	+		+		+		
Information Technology Workshop	B1	+		+		+	+	
Infotech: English for Computer Users	B1-B2	+	+	+	+	+	+	Interactive book
English for ICT Studies in Higher Education	B2-C2	+	+	+	+	+	+	

- The Improve Your Listening and Speaking for Future Software Engineering Professionals guide.
- The Business English Essentials for Software Engineers course book.
- The Dictionary of Acronyms and Abbreviations for Information Technology and Software Engineering Specialists.
- Methodological Recommendations for the Formation of Communicative Competence of Future Specialists in Software Engineering.
- Distant courses for studying English, English for Special Purposes, Business English and Profound English.

The Improve Your Listening and Speaking Guide is intended for students of IT specialities. It is aimed at teaching listening for better comprehending foreign language information, understanding general information, finding out the main ideas, extracting certain details or facts, and predicting key information before listening. The guide includes 24 sections covering a wide range of information technology issues: computer history, modern computers and their use in society, the Internet, global communications, wireless technology, computer games, digital libraries, software interfaces, graphical interface, software and others. The texts are selected from original modern sources, taking into account the latest trends in information technology and interests of modern students. The guide contains numerous diagrams, charts and illustrations that facilitate the perception of information and tasks. The manual includes audio files with scripts.

Each section contains a list of specific terms, listening tasks, and professional texts. The activities cover a number of questions that require not only specialized but also personal general knowledge regarding IT problems. Listening tasks vary in their form: answering questions, writing down terms, selecting facts in a report, filling in a chart or table using facts from a report, filling gaps, etc. After-listening activities typically involve discussion questions that develop speaking skills in the professional software engineering environment.

The Business English Essentials for Software Engineers course book is intended for senior students of IT specialities. It should be noted that the manual is designed to deepen the students' language skills in reading and speaking, improve their writing skills, as well as develop their ability to process original and prepare their own documents in English. The guide consists of 10 units covering the main types of business oral and written communication in software engineering. At the beginning of each block the list of active vocabulary is given. Post-text exercises are aimed at productive and reproductive activities. To simplify the processing of authentic and didactic materials, the guide contains a large number of samples of English-language documents in software engineering and information technology in general, intended for both classroom use and self-study. The information is retrieved and adapted from modern online materials and resources.

The Glossary of Software Engineering Acronyms and Abbreviations contains 12,000 terms and is intended for students who study IT and it is also useful for teachers of professional disciplines who train future IT specialists. The glossary also includes essential slang shortenings necessary for written communication among IT professionals and symbolic emoticons.

Methodological Recommendations for the Formation of Communicative Competence of Future Specialists in Software Engineering provide advice for oral and written communication in the work environment and in the software development process. The manual is intended for students who are interested in software engineering as a field of information technology, which deals with the application of a systematic approach to the development, use and maintenance of software, and the study of these approaches, i.e. the application of engineering principles to software. The manual also features an English-Ukrainian phrasebook for software engineering professionals. The guide contains 12 topics that address situations, problems, and tasks that arise during professional activities in software development. Tips on writing business letters and cover letters, talking on the phone, writing a resume, looking for a job, holding a teleconference, presentation or meeting using professional English vocabulary and word-specific words are provided. Useful phrases for communicating with clients and colleagues are also given. Each topic presents language patterns of business professional communication in the field of software engineering.

The materials of the manual are presented in the form of communication patterns, which are easily perceived by students in the learning process, because they have a standard structure and are used in typical professional situations. Having studied the language patterns, presented in both English and Ukrainian, grouped in the manual according to professional situations, students will quickly be able to recall them in real-world professional activities and demonstrate the high level of communicative competence.

Combining disparate means of communication and purposeful influence on the formation of communicative competence is enabled by distance learning technologies. In order to support the student self-study, distance learning courses for studying English (TSATU, 2021c), English for Special Purposes (TSATU, 2021d) and Business English (TSATU, 2021a) on the Moodle platform have been developed. The courses contain basic theoretical materials as well as additional materials: theoretical explanation of grammatical phenomena in the native language, audio and video materials with relevant tasks for understanding comprehension, conversational topics with tasks and comprehension check, texts for extracurricular reading with tasks. The main question types in the courses are those which are the best suitable for learning foreign languages: drag and drop into text, drag and drop markers, drag and drop onto image, essays, matching, gap fill, multiple choice, and true/false ones.

The topics of the course are in strict accordance with the curriculum of the discipline. The student progress in the course has been checked after each topic. In order to facilitate communication in a foreign language, a chat has been created in the distant courses to ask questions, leave comments, answer questions, and share useful information.

To enter the postgraduate course, students who have got the bachelor's degree are to pass the national entrance exam in a foreign language, so the foreign language training must include aspects of preparation for the exam. In this respect, the online profound English course has been developed because of the necessity to deepen the students' knowledge of English and to facilitate student training to pass the national entrance exam to enter the master's degree course. The units of the course cover general English topics: family and relationship, education, work, science and technology, etc. The course provides explanation of grammar rules, grammar materials, vocabulary lists and exercises for training. The emphasized aspects are reading and use of English, since namely these aspects are included in national entrance exam tasks.

5 CONCLUSIONS

Our research has made it possible to identify the progressive ideas of modern pedagogical science and to develop recommendations for improving the formation of communicative competence of IT specialists at higher education institutions. Vocational training of IT professionals in the 21st century should involve significant intensification of language training, whereby synergies should be achieved through a set of training measures of active vocational and linguistic training within separate practical courses; foreign language training should have the real-life flexible and variable context, taking into account the field of knowledge, its current state and sustainable development strategies and ideas. In the vocational training of IT professionals coherent problem modules with elements of private, business, academic professional and scientific communication in both oral and written formats should be implemented. It is necessary to emphasize that foreign language teachers need to modify the content, forms and methods of teaching foreign languages to meet the requirements of professional communities in order to ensure the proper level of English command.

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Modelling in GeoGebra in the Context of Holistic Approach Realization in Mathematical Training of Pre-service Specialists

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Keywords: Modeling Activity on GeoGebra, Mathematical Training of Pre-service Specialists, Holistic Education, Computer Dynamic Model.

Abstract: In accordance with its aim, the article represents students' modeling activity (held within inter-university projects of Kharkiv GeoGebra Institute) which resulted in the complex of GeoGebra models focused on holistic learning of Mathematics at higher school and university. Proper theoretical background for the complex design is elaborated and the stages of the students' modeling activity are covered. The models in the developed complex are grouped in the three sections. The first group consists of the models which enable to facilitate mastering basic essential mathematical concepts (objects) by the potential trainees. The second group is focused on the realization of transdisciplinary connections between Mathematics and other subject domains. The third group embraces models which provide real-life problems solving based on the models investigation. All the groups are represented in the article along with specific examples of the models. In order to facilitate potential trainees' personal cognitive activity that is expected by holistic education, it was elaborated procedure of cognitive activity which includes some tips on changing the parameters of the dynamic model, monitoring the results, investigating, making conclusions etc. Such a procedure is aimed to streamline understanding the essence of the concept (phenomenon). The didactic support for each model was developed by the students to involve potential trainees into the solving special problems and real-life tasks which encourage them to obtain holistic understanding of the basic concepts via special cognitive activity based on work with dynamic models. The said didactic support is characterized in the paper. The prospects of further research are outlined.

1 INTRODUCTION

The analysis of the evidence of university and pre-university mathematics training as well as the results given in recent studies (Bobyliev and Vihrova, 2021; Elkin et al., 2017; Semenikhina and Drushliak, 2014; Singh, 1996; Vlasenko et al., 2019), testify the number of drawbacks of contemporary school mathematics training which then lead to the difficulties faced by the university students and raise the problems of increasing the level of mathematical education both at school and university.

According to the (Bevz, 2003; Bilousova et al., 2019; diSessa et al., 2004), the most common learning difficulties which brake the process of successful mastering mathematics are the following. Students find mathematical concept to be difficult to take in and to apply them properly to practical tasks. It leads to inability to achieve basic educational goals by the students which results in their loosing interest to Mathematics. Finally, it becomes impossible for the students to see the beauty of the science and to appreciate its importance for mastering other knowledge domains.

One of the essential problems of mathematical training that can cause the learning difficulties is the absence of holistic understanding of mathematics as a

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basis and tool for solving interdisciplinary tasks and real-life problems. Unfortunately, for the most of students, Mathematics remains too abstract curriculum subject which is really complicated and distracted from real world. Hence, the students are demotivated to master it and feel true necessity to its deep understanding.

The said problems of mathematical training which are faced nowadays by the pre-service specialists of different majors cause the necessity of finding and applying new approaches to mathematics learning. One of such approaches seems to be holistic educational paradigm which aims to provide dynamic, harmonized, and interconnected ways of learning.

According to the research on the holistic approach, the core concept of holistic education is the cohesive development of the students' personality both at the intellectual and emotional levels (Singh, 1996). In addition, it is underlined that the said cohesive progress should base on the links between real-life problems and personal experience of a trainee.

Among basic principles of holistic education the studies (in particular, (Mahmoudi et al., 2012; Miller, 2004, 1991; Miller et al., 2005)) point out some pillars which seem to be essential in the context of the problems of Mathematics training, mentioned above. The first principles expects students' freedom and autonomy. So, within the holistic paradigm any trainee is considered to be really active participant of the learning process who is ready to interact with reality through his own cognitive activity with his own ups and downs.

Next pillar of the holistic approach is necessity to establish connections and relationships between the object of learning and existing knowledge. The more links trainees have, the stronger memories are formed in their minds and better understanding of the whole they obtain.

Similar to the establishing links is the principle of transdiciplinarity which focuses teaching and learning on ruining boundaries between subject fields themselves as well as between subject areas and reality.

Researchers also point out that holism helps both the connection facet and transdiciplinarity, because it seems to be fruitful to learn separate things which in fact are not separate. However, at the same time it is necessary to understand how they work together.

The analysis of the holistic education basis reveals a need to apply efficient learning tools enabled to provide holistic approach to nowadays teaching and learning.

One of such tool seems to be computer dynamic models (CDM). The learning of recent studies on their didactic facilities testifies that CDM have quite powerful potential as for revealing transdisciplinary connections and facilitating their understanding by trainees. In particular, researchers point out that CDM are typically based on the mathematical model of a concept (process, phenomenon, etc.), and enable to visualize its essence at real time operation, learn dynamic changes, and investigate the concept or process via active cognition. In such a way CDM help to form and develop students' techniques of mental activity including transdisciplinary ones (Semenikhina and Drushliak, 2014; Alessi, 2000).

Characterizing advantages and facilities of CDM using in the context of holistic education, it is important to emphasize that they encourage students to learn objects independently and actively. In addition, they reveal and demonstrate in action the wholeness of the learnt concepts (phenomenon).

In this context, it is essential to focus on the valuable potential of contemporary mathematical computer environments which enable to create the models of different complexity, visualize changes of the model behavior and do proper research. Despite the great variety of the said software on the modern IT market, we would like to focus on modeling facilities of free GeoGebra software which provides a trainee with convenient tools to develop a CDM, and do effective simulations and investigations with it. In particular, GeoGebra allows to create geometrical objects and obtain easily their algebraic interpretation; get interactive and dynamic visualization of the objects of various essence; manipulate with the model parameters to monitor the changes etc (Pikalova, 2018; Kramarenko et al., 2020). In addition, online service GeoGebraTube grants the access to the variety of existing elaborations provided by the global GeoGebra community which unites the educators and students all over the world.

Nowadays, GeoGebra Institutes work in many countries and make together International GeoGebra Institute (IGI) as a global organization that nourishes and stimulates collaboration between practitioners and researchers, seeking to expand the community of independent GeoGebra users.

GeoGebra Institute, Kharkiv, Ukraine, which has been realizing its mission since 2010 within IGI, focuses on:

1) promoting the dissemination and productive use of software, scientific, educational, methodological developments of the international GeoGebra community in professional activities of mathematicians and other specialists;

2) encouraging students and teachers to conduct research in mathematics, physics, computer science and information technology;

3) implementation of the concept of STEM-education in educational practice;
4) involvement of students and teachers in cooperation with the international GeoGebra community via participation in the conferences and other events initiated by the IGI.

One of the interesting and significant inter-university projects of Kharkiv GeoGebra Institute was involving students of various specialties into modeling activity focused on various GeoGebra models elaboration and learning the modeled objects (processes, dependences etc.).

The purpose of the article is to represent students' modeling activity which resulted in the complex of GeoGebra models focused on holistic learning of Mathematics at higher school and university.

2 THEORETICAL FRAMEWORK

During the research, the set of theoretical, empirical, and modelling methods were applied.

Characterizing the arrangement of the said students' modeling activity within Kharkiv GeoGebra Institute, we can describe all necessary stages of the work.

At the first stage, the core task was formulated for the students as following: to develop the complex of GeoGebra models for the maintaining learning of Mathematics at higher school and university based on holistic approach.

In addition, there were formulated necessary requirements for the whole complex which determined its potential functions and enabled to realize exactly holistic paradigm according to its aim and principles (covered above).

In accordance with Requirement 1, the students had to develop different groups of models. The first group consists of the models which enable to facilitate mastering basic and complicated mathematical concepts (objects) by the potential trainees. The second group of the models must be focused on the realization of transdisciplinary connections between Mathematics and other subject domains. The third group has to provide real-life problems solving, based on the models investigation. Such models and simulations should emphasize the meta-role of Mathematics as well as demonstrate its practical value (rather than pure abstract science).

Requirement 2 determined all the models to be dynamic, to visualize immediately the results of the trainee's manipulation and encourage them to learn the modeled concept actively, via their own experience.

Requirement 3 expected the complex to be cloud-based, that is, to be available at www.geogebra.org for the global GeoGebra community. According to recent studies, cloud-based learning environment for teaching and learning STEM disciplines opens wide horizons for holistic education due to the realized support for various processes of learning and research activities; great level of learning resources flexibility; integration of variety of educational components based on innovative technologies. On the other hand, it seems to be powerful motivational factor for the students evolved into the complex elaboration as their work makes them participants of the global community.

Thus, at the first stage of the modeling activity, the students had to understand main features of holistic theory, to realize their core task and the common requirements to the complex, plan the work and allocate sub-tasks.

Next stage of the work was analytical one which created necessary theoretical background for development of all three groups of dynamic GeoGebra models.

At this stage of the complex elaboration the students made deep and comprehensive analysis of Mathematics to reveal its key concepts and their potential links with the notions of other subject domains. In order to meet the main pillars of holistic educational approach (covered earlier) it is necessary to reveal key objects of learning in the subject areas, establish connections between them, and build chains of proper transdisciplinary links.

Researchers distinguish different types of transdisciplinary connections. However, scientists (in particular, Bevz (Bevz, 2003), diSessa et al. (diSessa et al., 2004), McDonald and Czerniak (McDonald and Czerniak, 1994)) recommend to base the connections classification upon the set of three main grounds: information content of the subject domain, structure of learning activity, and organization of educational process.

As a result, considering the transdisciplinary connections from the standpoints of holistic education, the students had to reveal key concepts of subjects, detect their place in the current curriculum, consider peculiarities of their mastering and proper cognitive activity.

These procedures were done through the learning main content threads of the said curriculum subjects (Ministerstvo osvity i nauky Ukrainy, 2017a,b) and didactic analysis of each subject domain (covered in (Gryzun, 2018, 2016)). Main content threads of Mathematics, Science subjects (Physics, Chemistry, Biology) and Computer Science enabled us to reveal some transdisciplinary chains. We would like to point out a paramount role of penetrating content threads in revealing transdisciplinary concepts and links between them. According to the Concept of the New Ukrainian School, there are four penetrating content threads – “Ecology security and sustainable development”, “Civil responsibility”, “Health and security”, “Financial literacy” – which are seen as a mean of key competences integration of all curriculum subjects. The penetrating threads are considered to be socially important meta-topics that focus teaching and learning on the trainees’ holistic understanding of the world. They are recommended to be regarded during the learning environment creation at all the levels of education (Elkin et al., 2017).

Finally, at the analytical stage of the described modeling activity, the students obtained the set of connection chains between the Mathematics and other subject domains. In particular, there were revealed the links:

- Mathematics – Computer Science;
- Mathematics – Physics;
- Physics – Mathematics – Biology;
- Mathematics – Economics;
- Mathematics – Building (design) and others.

Subsequent detailed analysis of the qualification standards, textbooks, and subject areas resulted in establishing of transdisciplinary links between the learning elements (LE), representing concepts and phenomena which are co-explored by several subject domains. In particular, the effective semantic analysis was held with the help of specialized software, such as: TextAnalyst 2.0, Text Miner 12.1 (its Text Parsing Node), Trope 8.4.

Such a “smart” analysis of the subject areas enabled to distinguish the weightiest LEs of the specific subject area along with their conceptual links. Basing on the depicted analysis, for the revealed weightiest LEs of Mathematics it was built a graph, representing their transdisciplinary links with exact learning elements (LE1...LEn) of other subject domains (SD), according to the chains of connections mentioned earlier.

The general scheme of the graph representing their transdisciplinary links with exact learning elements (LE1...LEn) of subject domains (SD) as well as the example of the graph for selected LEs, representing the transdisciplinary links for the chain: Physics-Mathematics-Biology (Used below for the transdisciplinary Model “Lens”), are given on the figures 1 and 2.

3 RESULTS AND DISCUSSION

The results of theoretical framework were used by the students at the design stage of their modelling activity on the development of the complex of GeoGebra models, focused on holistic learning of Mathematics at higher school and university.

The process of the models elaboration provided by the students (with accordance to the requirements formulated at the preparation stage) embraces some phases. At the first phase mathematical model of the future computer model is built. At this point it is done:

1) revealing and learning of the transdisciplinary essence of the proper concept (See theoretical framework);
2) defining of the mathematical dependencies which can illustrate and investigate the concept;
3) determination of the fixed model parameters and changeable ones along with the range and step of their changes;
4) picking up proper graphic elements which are able to illustrate dynamic changes;
5) revealing of transdisciplinary tasks and real-life problems which might be solved by the model;
6) elaboration of didactic support as a scheme of work upon the ransdisciplinary tasks and real-life problems directed on the forming holistic image of the said concept (phenomenon).

At the second phase the mathematical model is built in the environment of GeoGebra. In particular, the set of standard GeoGebra tools are used (Points, Lines, Special Lines, Polygon, Circle and Arc, Measurement, Transformations) as well as the CAS components (Calculations and Analysis Tools). For realization of dynamic transformations, the Action Object Tools and Movement Tools are used (Semenikhina and Drushliak, 2014; Pikalova, 2018).

In order to make the use of the complex more flexible and available to a wide community of students and teachers, it was organized it in the form of GeoGebra Book. GeoGebra Book is a cloud service which enables to gather GeoGebra resources, to enhance them didactically, and to share them easily. Due to this fact, the complex of models is oriented to be a component of a cloud-based learning environment available to the global GeoGebra community.

The third phase is devoted to the testing, debugging and improving of the model.

The models in the complex are grouped in the three sections according to the Requirement 1: the

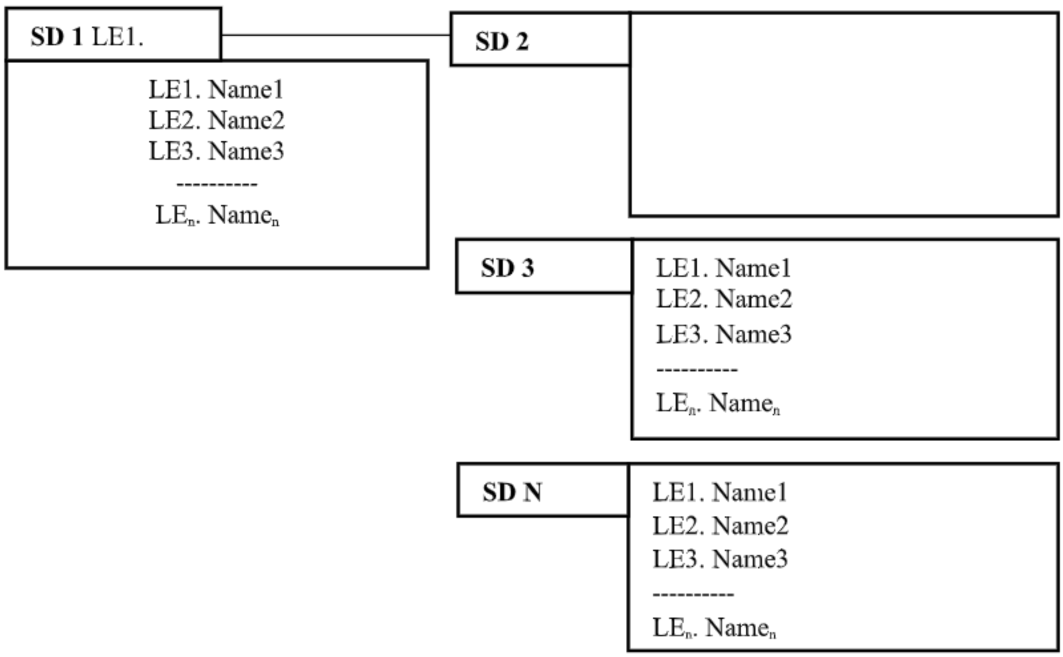

Figure 1: The common scheme of the graph, representing their transdisciplinary links with exact learning elements (LE1...LEn) of subject domains (SD).

first group consists of the models which enable to facilitate mastering basic and complicated mathematical concepts (objects) by the potential trainees; the second group is focused on the realization of transdisciplinary connections between Mathematics and other subject domains; the third group embraces models which provide real-life problems solving based on the models investigation.

Each of the models is presented in the complex according to the general scheme.

It includes (see examples below):

- model title;
- chain of the transdisciplinary links which are illustrated by the model;
- model description which explains concept (phenomenon) that is a prototype of the model;
- dynamic model itself with a proper functionality;
- procedure of cognitive activity on the realizing the essence of the concept (phenomenon);
- didactic support as a set of transdisciplinary tasks and real-life problems for forming holistic image of the said concept (phenomenon), and a scheme of work upon them;
- graph of the revealed transdisciplinary links for the visualization and remembering this holistic representation.

As it was mentioned above, holistic education expects trainees' personal cognitive activity. In order to facilitate it, it was elaborated procedure of cognitive activity which includes some tips on changing the parameters of the dynamic model, monitoring the results, investigating, making conclusions etc. Such a procedure is aimed to streamline understanding the essence of the concept (phenomenon).

The didactic support for each model is developed to involve potential trainees into the solving special problems and real-life tasks which encourage them to obtain holistic understanding of the basic concepts via special cognitive activity based on work with dynamic models. All of the tasks focus the trainees on the revealing and realizing transdisciplinary links.

Some of the models with their description and functionality are included into more than one subject section. However, didactic support as a set of transdisciplinary tasks for each model is specific in each section and focuses on different transdisciplinary connections.

Below we demonstrate fragmentary some of the models from various groups of the complex created by the students within the modeling activity (according to general scheme of model presentation depicted above) and offer recommendations as for their using to provide holistic learning of Mathematics at high school and university.

As it was said above, the dynamic models of the

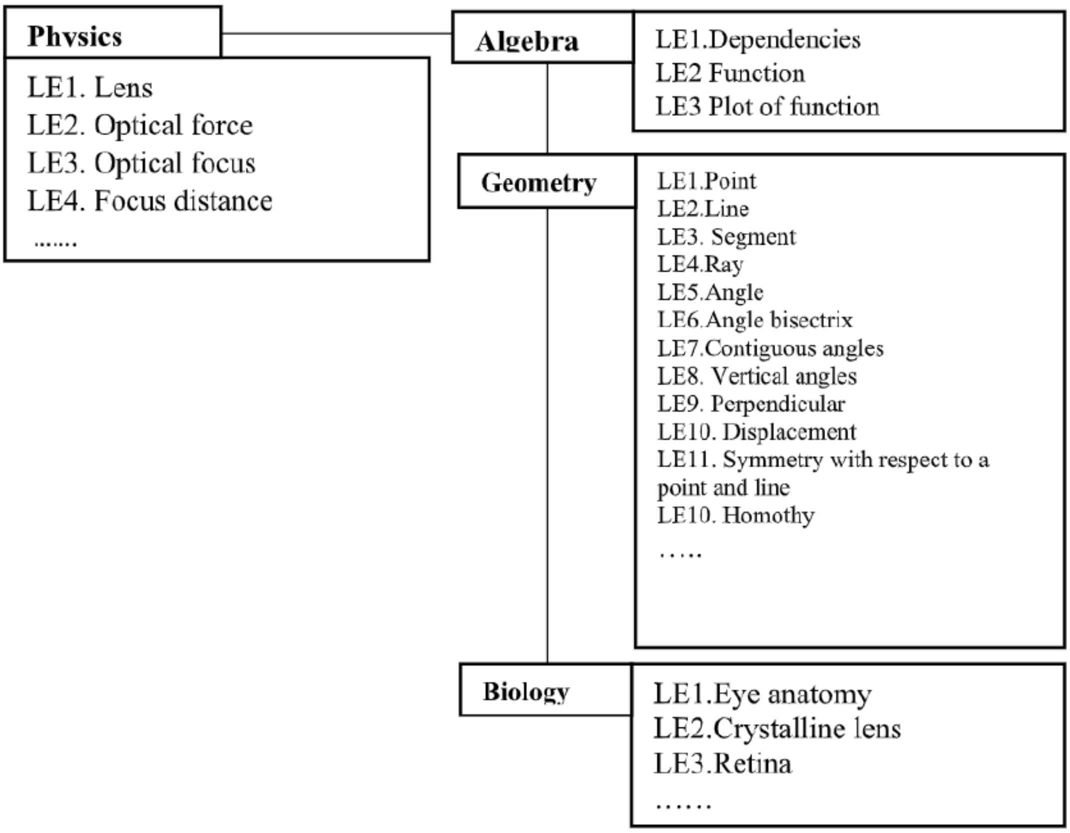

Figure 2: The example of the graph for selected LEs, representing the transdisciplinary links for the chain: Physics-Mathematics-Biology (Used below for the transdisciplinary Model "Lens").

first group enable to facilitate mastering basic and complicated mathematical concepts (objects) by the potential trainees. The models are accompanied by special didactic support focusing them on investigation and holistic learning of the modeled concept. A lot of the models expect the model transformation by a trainee with the aim of its extension on different class of problems.

Among the models of this group it is worth mentioning the models *Elementary functions investigation* (figure 3), *Triangular properties learning, Graphical inequalities solution, Calculation of the area limited by the curve* (figure 4), *Remarkable curves investigation, Investigation of the approximation curve* and others.

Example 1. Model "Remarkable curves investigation. Epicycloids"

Chain of the transdisciplinary links: Geometry-Algebra-Mechanics.

Model description: According to definition, epicycloids is a plane curve made by tracing the path of the fixed point P on the circumference of a circle (called epicycle) which rolls without slipping around another fixed circle. R is the radius of the fixed circle, r is the radius of the rolling circle. The model is built based on the kinematic definition of epicycloids and illustrates its different types. Unlike cycloid, epicycloids are not transcendental.

Procedure of cognitive activity with the model (selected tasks of the elaborated didactic support by the students):

1. Manipulate the model parameters to figure out how the number of the curve lobes depends on the ratio n of R and r. Answer the questions:
   - What types of epicycloids is obtained at n=1, n=2, n=3?
   - What happens, when n is integer and when n is rational? Make conclusions.
2. Monitore the model work, and calculate position of the point P via radiuses (R, r), the radian from the tangential point to the moving point and the radian from the starting point to the tangential point.
3. Transform the original model of epicycloids into the model of hypocycloid, answering the ques-

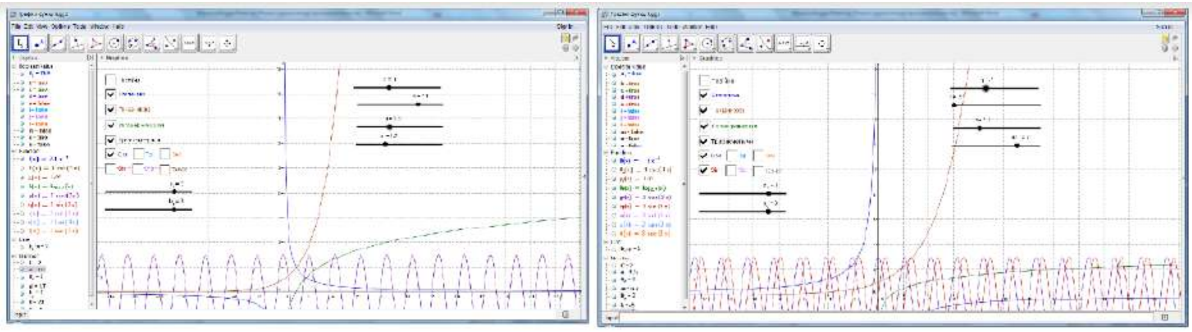

Figure 3: Episodes of cognitive activity on the model *Elementary functions investigation*.

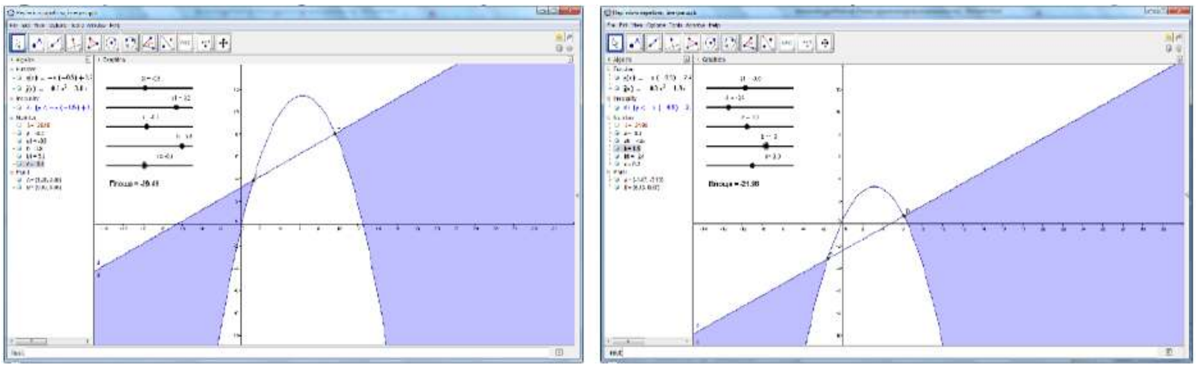

Figure 4: Episodes of manipulation with the model *Calculation of the area limited by the curve*.

tions and doing proper steps:

- How to calculate R now, when the small circle "rolls" along inside part the bigger circle?
- How to calculate the speed of the point P which remain the trace? Why?
- How must animated points P and the center of smaller circle move now? How are their movement directions related?

4. Use obtained model of hypocycloid, monitor its work and convince that its number of cusps is also controlled by the ratio n. Investigate the curve behavior, answering the questions:
   - How many cusps does the curve have, if n is integer n?
   - How is hypocycloid transformed at n=2?
   - What value of n stops the work of the model? Why? How does the curve look like?
   - Investigate the curve behavior at $1<n<2$ and $n>2$. Make conclusions.

Selected episodes of the students' cognitive activity with the dynamic model "Remarkable curves investigation. Epicycloids" are given on the figure 5.

The models of the second group are concentrated on the realization of transdisciplinary connections between Mathematics and other subject domains. In particular, it contains the models *Clock* (connections: algebra, geometry, trigonometry, physics, sociology, history, philosophy); *Mathematical pendulum* (connections: mathematics, physics) (figure 6); *Number systems* (connections: algebra, computer science, discrete mathematics, history); *Binary tree* (connections: discrete mathematics, computer science) (figure 7) and many others.

Work upon the transdisciplinary models of the second group is selectively shown in the Example 2 below.

Example 2. Model "Lens"

Chain of the transdisciplinary links: Physics-Mathematics-Biology.

Model description: The model illustrates principle of operation of a lens as a simplest optical device that focuses or disperses a light beam. A lens consists of a single piece of transparent material (e.g. glass or plastic). A lens can focus light to form an image which differs it from prism (See Model "Optical dispersion"). A lens has its optical axis, two focuses, main optical center and plane (you can find their definitions in your textbook). Lenses are classified by the curvature of the two optical surfaces. The model demonstrates the operation of exactly biconvex lens.

Procedure of cognitive activity with the model (se-

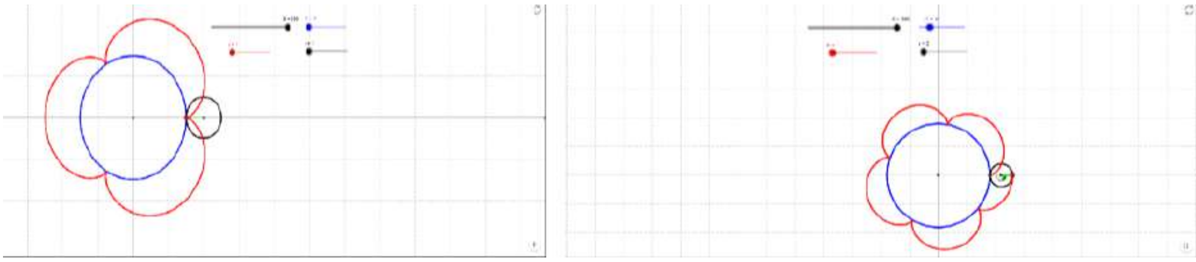

Figure 5: Episodes of the students’cognitive activity with the dynamic model “Remarkable curves investigation. Epicycloids”.

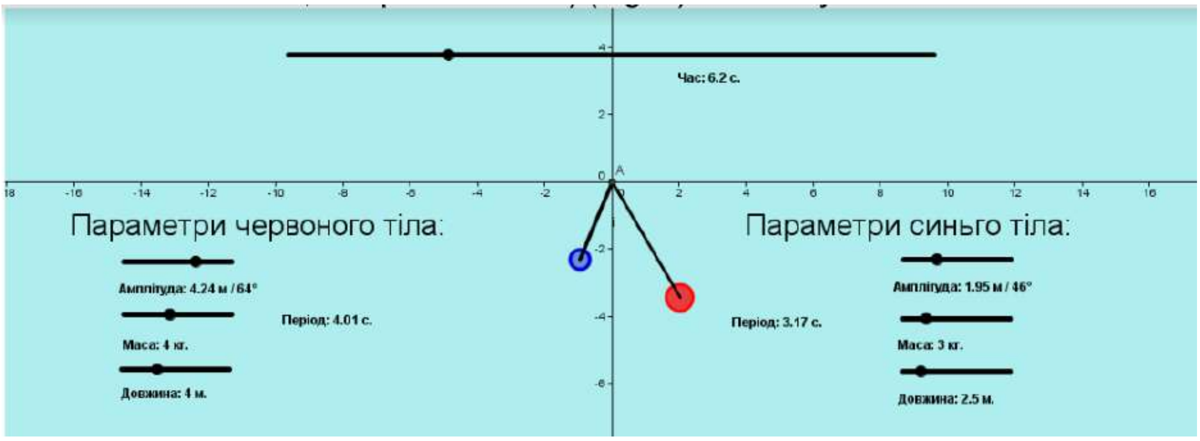

Figure 6: Episodes of the students’cognitive activity with the transdisciplinary model *Mathematical pendulum*.

lected tasks):

1. Operate the model. Change curvature with the slider. Monitor the focuses positions and image positions. Find and formulate dependences.
2. Fix the lens curvature and change the object position relative to the focus. What is happening with the image of the object?
3. Fix the object at the distances: d=2F, d>2F, d<2F. Analyze changes and make conclusions.
4. Analyze changes of the image’s size and position when the object is between 2F and F, between F and lens center.

Fragment of didactic support as a set of transdisciplinary tasks and real-life problems for forming holistic understanding of the optical device from the standpoint of Mathematics, Physics, and Biology):

1. Manipulate the model parameters. What is mathematical dependence between object distance to the lens and focus distance? How is it called? Write the formula of the dependence.
2. What geometrical figures describe the object, its image, light beams and the phenomena of light penetration through the lens?
3. What geometrical facts and properties are revealed by the device operation?
4. Which angles are equal at any values of the model parameters? Why? Which rays are parallel? Why?
5. Working with the model, detect the parameters of the model which provide the highest optical power of the lens.
6. Manipulating the model and using the scheme of the optical system of a human eye (figure 8), answer the questions: (1) what are the components of the eye optical system? (2) what is the difference between real and virtual image? (3) what are the basics of a human eye functioning from the standpoint of physics? (4) can you explain eyesight disorders (short sight, long sight, etc.) via physical concepts and phenomena? (5) compare the principles of human eye operation and work of a digital camera.

Episodes of transdisciplinary tasks doing and the model operating are shown on the figure 9.

Graph of the revealed transdisciplinary links for the visualization and remembering this holistic representation presented on figure 2 above.

The third group of the created models embraces ones that provide real-life problems solving based on the so called STEM investigation. As it is expected by the requirements, the models of the third group enable simulations which help realize the meta-role of

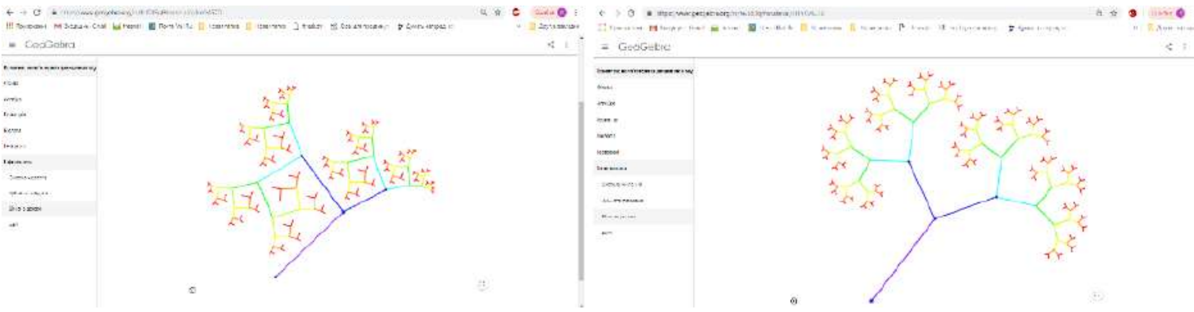

Figure 7: Episodes of the students'cognitive activity with the transdisciplinary model *Binary tree*.

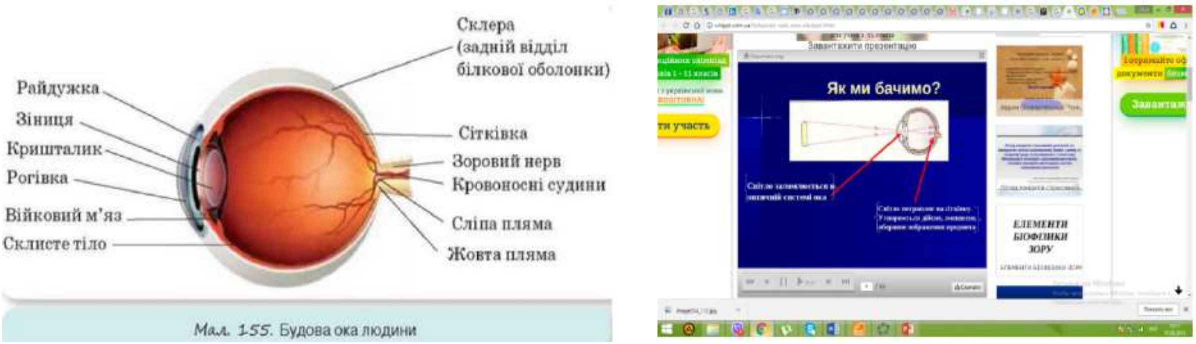

Figure 8: Scheme of the optical system of a human eye.

Mathematics as well as demonstrate its applied value for practical daily needs. It includes the models such as *Investigation of shooting path; Lift work; Geometrical transformations in real-life measurements; Remarkable triangular points; Bridge approximations* and many others.

Selected fragments of the real-life tasks solving within the dynamic models *Investigation of shooting path* and *Geometrical transformations in real-life measurements* are given on the figure 10.

Below we are giving the example of STEM investigation which it is recommended to build, maintaining the model *Fermat-Torricelli points investigations*.

Example 3. Real-life problems solving on the model *Fermat-Torricelli points investigations*

Investigation 1. Construct the second Fermat-Torricelli point by constructing right triangles on the sides inward. Investigate the properties of the Fermat-Torricelli point: the sum of the distances from the point to the vertices of the triangle is minimal, and all the vertices are visible from it at an angle of 120°.

Investigation 2. Using the obtained dynamic model, investigate the position of the Fermat-Torricelli point (with to the triangle), when the triangle has one angle greater than 120°. Determine whether it will have its properties in this situation. Determine how the point will behave when there is an angle of 120°.

Investigation 3. Elaborate the model and try to figure out how to use the properties of the point to solve current problems in your city.

1. Imagine that you need to place the emergency medical center so that it was at a minimum distance from the three points of the city A, B, C. Using a digital map of the city as a working geometric field GeoGebra.

2. Match the points of the city to the vertices of the triangle and determine if there is a Fermat-Torricelli point for this triangle, find this point for it.

3. Determine which geographical point on the map corresponds to the found Ferma-Torricelli point. Investigate whether it is possible to locate an emergency center at this point in terms of social, economic and geographical conditions.

4. If this is not possible, manipulate the model parameters, change the position of the points A, B, C and find out their geometric location so that the built triangle and its Ferma-Torricelli point meet the current social needs of the city.

Investigation 4. Formulate a mathematical problem about the use of the properties of the Ferma-Torricelli point, which can arise when building roads

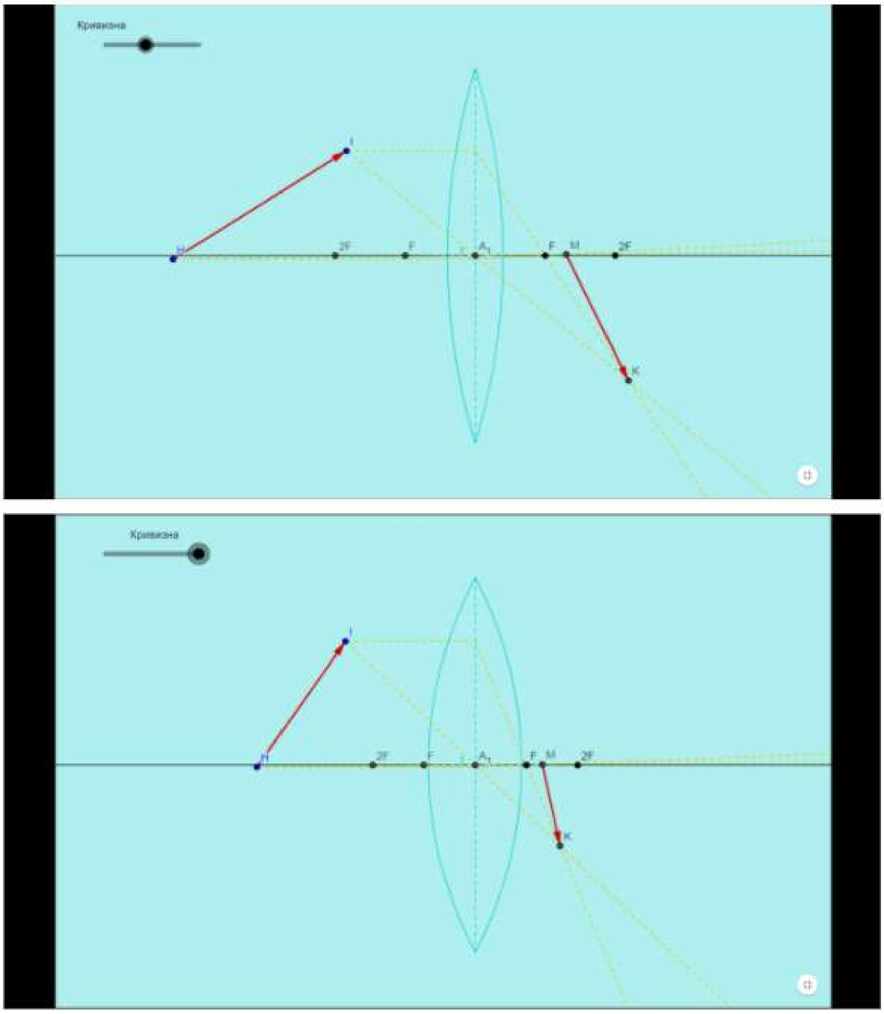

Figure 9: Episodes of transdisciplinary tasks solving, operating the model “Lens”.

between settlements in your region in order to save resources. Use the dynamic model to solve and investigate this problem.

Summarizing the presentation of the complex of GeoGebra dynamic models created by the students (pre-service specialists of different specialities) within the realization of holistic approach to their mathematical training, we would emphasize that besides models, the students developed special didactic support as a set of transdisciplinary tasks and real-life problems for forming holistic image of the said concept (phenomenon).

The prepared didactic support includes the transdisciplinary tasks of various types. In particular, there are tasks on establishing connections between mathematical concepts and notions of other subject areas. The aim of these tasks is to specify and generalize mentioned connections; to form the system of the notions of different level of generalization and subordination; to illustrate casual relations of phenomena. This type of the problems are directed on the forming of the set of potential trainees’ skills of integrative properties: to understand meta-role of Mathematics for other domains of knowledge; to explain processes and phenomena of one domain with the help of concepts of other branch; to make outlook conclusions based on common concepts, and others.

Besides, the developed didactic support can offer transdisciplinary tasks for potential trainees on the determination of community of the facts from different subject domains. They allow to specify learning material, to form new mathematical concepts and explain them from the standpoints of other branches of science, to use some mathematical facts to illustrate other ones. Such tasks are aimed at the forming students’ skill of facts’ analysis, generalization and

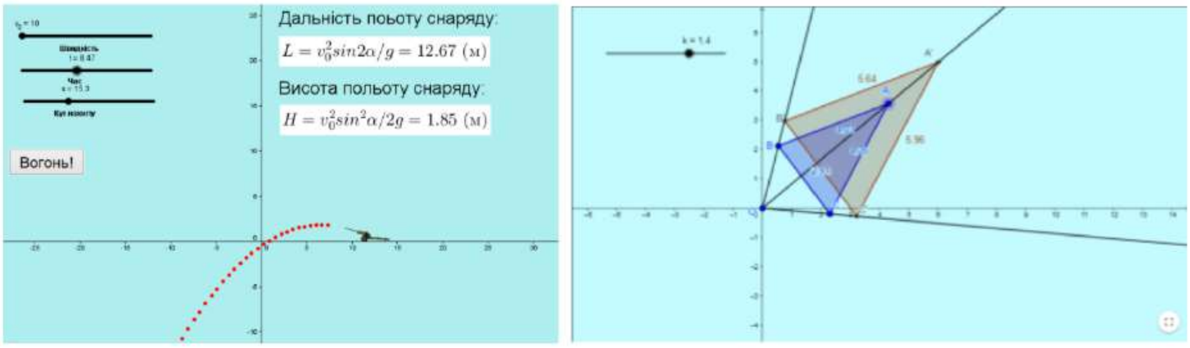

Figure 10: Selected fragments of the real-life tasks solving within the dynamic models Investigation of shooting path and Geometrical transformations in real-life measurements.

explanation from the standpoint of general scientific ideas; skill to integrate generalized facts into the existing knowledge system; skill to apply generalized knowledge into practice.

In addition, into the didactic support there are included the tasks on the establishing connections between theoretical knowledge and methods, and their practical use. Mostly they are real-life problems which focus on the ruining boundaries between Mathematics, other subject domains and reality. They might help to form the trainees' ability to see scientific subtext in pure practical tasks, to attract generalized knowledge from related areas, and to apply them to resolving the problem.

Thus, the cloud-based complex of GeoGebra models (created by the pre-service specialists of different specialities) as for their functionality provides main principles of the holistic education, such as connections establishing, personal cognitive activity, focus on the ruining boundaries between subject fields and reality.

It seems to be relevant to predict positive influence of the complex application on the forming of potential trainees' holistic system of mathematical knowledge.

In addition, we would like to point out that the complex is a result of modeling activity of the students within the realization of holistic approach to their mathematical training. In this context, our observations and monitoring all the stages of the students'simulation work in the process of the complex development, allow to predict not only raising the level of their mathematical knowledge. Our monitoring programs and regular surveys also testify definite impact on the level of the students' investigative (enquiry) skills. In particular, there was detected positive dynamic of cognitive, motivational and behavioral components of the said skills. Generalization and statistical analysis of the obtained empirical results make prospects of our research.

4 CONCLUSIONS

In accordance with its purpose, the article represents students' modeling activity (held within inter-university projects of Kharkiv GeoGebra Institute) which resulted in the complex of GeoGebra models focused on holistic learning of Mathematics at higher school and university.

Proper theoretical background for the complex design is elaborated and the stages of the students' modeling activity are covered. The models in the developed complex are grouped in the three sections. The first group consists of the models which enable to facilitate mastering basic essential mathematical concepts (objects) by the potential trainees. The second group is focused on the realization of transdisciplinary connections between Mathematics and other subject domains. The third group embraces models which provide real-life problems solving based on the models investigation. All the groups are represented in the article along with specific examples of the models.

In order to facilitate potential trainees' personal cognitive activity that is expected by holistic education, it was elaborated procedure of cognitive activity which includes some tips on changing the parameters of the dynamic model, monitoring the results, investigating, making conclusions etc. Such a procedure is aimed to streamline understanding the essence of the concept (phenomenon). The didactic support for each model was developed by the students to involve potential trainees into the solving special problems and real-life tasks which encourage them to obtain holistic understanding of the basic concepts via special cognitive activity based on work with dynamic models. The said didactic support is characterized in the paper.

The prospects of further research are outlined.

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Use of YouTube Resources in the Process of Training German Language Teachers

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Keywords: YouTube, Video Hosting, German Language, Foreign Language Competence, Autonomy.

Abstract: Integration of ICT significantly increases the possibilities of the educational process and extends the boundaries of the educational sphere as a whole; it is also a necessary condition for the implementation of distance learning. Publicly available resources, such as e-mail, blogs, forums, online applications, video hosting sites, can serve as the basis for building open learning and education. Informational educational technologies of learning foreign languages are in the focus of this study. The article represents the results of theoretical analysis of content on the subject of its personal- and didactic-definite orientation, as well as some aspects of the practical use of commonly used YouTube video materials in the process of teaching German as the first or second foreign language in higher education, namely at the pedagogical university. Taking into account the practical experience of using the materials of several relevant thematic YouTube channels with a fairly wide constant audience, a concise didactic analysis of their product is presented and recommendations on converting video content into methodological material in the framework of practical course of German language by future teachers are offered. Possibilities of using alternative resources of YouTube in terms of distance learning in view of mediation skills development in the interpretation of this concept by authors of CEFR Companion Volume with New Descriptors (2018) are considered. Four groups of resources that can be used as teaching materials are identified and analyzed; some examples of their preparing and use by the training of future foreign language teachers are offered. The focus was also on open resources ONCOO and TWINE, which can be used in particular to develop the autonomy of future foreign languages teachers, and the capabilities of these resources are characterized. Due to the suggested recommendations, the following tasks can be solved: enrichment of the vocabulary; semantization of phraseological units, constant figures of speech, cliché; development of pronunciation skills; expansion of linguistic and ICT competences; improving listening and speaking skills; increasing motivation to learn, etc.

1 INTRODUCTION

Information and communication technologies, which are gradually integrating into education, expand its boundaries and create additional opportunities for the educational process. The global crisis of 2020, on the one hand, proved the need to intensify the gradual development of open learning and education is based on the latest information technologies and open resources, among which web services are particularly appealing in recent times, which allow you to download and view videos in your browser. On the other hand, it overemphasized the importance of the teacher's contribution to society. Distance learning (Bobyliev and Vihrova, 2021), digitalization (Strutynska et al., 2020) and integration (Kanevska and Hostra, 2020) are no longer just buzzwords; they are now the basis of the educational process. The problem of training and advanced training of personnel, development of autonomy as a component of educational competence (both students and teachers), and expansion of competence in the use of ICT (Modlo et al., 2018) was especially relevant, which led to changes in the Qualifications Framework.

YouTube (YouTube, 2021), as a video hosting,

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provides video hosting services, from amateur videos to professional video clips and videoblogs. Nowadays it is one of the most visited sites in the world of the Internet due to the simplicity and ease of use, the ability to communicate without time and territorial restrictions, sharing views in the comments on the videos.

According to statistics from recent years, “education” is consistently included in the top ten most popular categories of video, attracting the attention of billions of regular users from around the world. It should be noted that education occupied a rather high sixth place with 38.6 billion views and 2.9 billion regular users. This allows to enroll confidently video hosting to modern learning tools, in particular, of German language.

About 80 million videos were found on YouTube in four languages (Ukrainian, Russian, German and English). You can find videos of different specializations on YouTube. Table 1 summarizes the information of the orientation of the authors of the numerous channels of video materials, which are offered to everybody, who is interested in learning German as a foreign language.

However, the issue of increasing the efficiency of the use of video materials disseminated through the platform in the process of learning German in a higher education institution, in particular in the context of distance learning, remains relevant.

2 THEORETICAL COMPREHENSION OF YOUTUBE POSSIBILITIES IN EDUCATION

Analysis of last researches and publications worldwide indicates an increase of the number of authors who devote their works to the problems of using YouTube in teaching foreign languages. The highest level of interest is shown in learning English as a foreign language. This is due to the status of this language in the modern world as lingua franca.

The subject covers a wide range of issues. In particular, Arndt and Woore (Arndt and Woore, 2018) aim to compare the processes of forming the vocabulary of the second language as a result of interaction with two network media: written blog posts and video blogs. In this analysis the level of assimilation of various aspects of lexical knowledge (spelling, semantic and grammatical) was a subject. In turn, Saudi Arabia scholars have experimentally demonstrated higher productivity of targeting vocabulary in a multimedia environment using video on YouTube compared to the traditional way of learning with images (Kabouha and Elyas, 2015).

Antoro (Antoro, 1705) explores the use of ICTs, including YouTube, as key tools for creating training materials in order to support distance learning and language learning.

The experimental study of Iranian scholars Souzanzan and Bagheri (Souzanzan and Bagheri, 2017) is concerned with the problem of perceiving English as a foreign language in the context of expediency of ICTs use, in particular YouTube, during individual learning.

Brazilian researchers Chimenti and Lins (Chimenti and Lins, 2016), having analyzed the impact of some digital resources on the quality of teaching English at elementary school concluded that the latest ITs could make learning of foreign languages more contextualized, creative and motivated.

On the strength of the assertion, that life-satisfying learning is the best policy for learning English (especially by children), Lee et al. (Lee et al., 2016) believe that the video is a good bearer of information that is the most suitable for language learning. First of all, it is a great opportunity to capture real life situations, and secondly, it is easy to access the necessary information through YouTube.

According to Cakir (Cakir, 2016), due to the emergence of numerous open sources of information (YouTube, Facebook, Twitter, Internet newspapers and magazines) during the globalization period, we are able to observe the phenomenon called “Teaching English to the Speakers of Other Languages” (TESOL) as well as “Teaching English as a Language of Open Sources” (TELOS). TELOS can provide expected multimodal and multidimensional support for TESOL (especially in the context of learning English as a foreign language), enabling the acquisition of pragmatic skills (in particular semantic-syntactic skills), which can only be partially formed in traditional lessons, according to Cakir (Cakir, 2016).

According to Bastos et al. (Bastos et al., 2015), YouTube acts as a cognitive tool, which is able to promote raise of the level of critical thinking and cognitive ability of students in the process of learning English as a foreign language.

The analysis of experimental data (Winter, 2015) showed that the use of existing videos and creation of their own videos for the distribution through video hosting increases the motivation of students to learn foreign languages.

Multifunctionality and effectiveness of YouTube as a tool for learning foreign languages is thus evident.

The purpose of the submitted report is:

Table 1: Orientation of educational videos.

Personal-definite orientation	
by age	– for children – for teenagers – for adults
by level of language proficiency	– for beginners – according to the levels of the European Language Education Recommendations
by line of work of users	– for pupils – for students – for professional purposes
Didactic-definite orientation	
by aim	– development of certain linguistic competence (lexical, grammatical) – preparation for the examination to confirm the level of language proficiency – everyday communication – communication in a professional environment
by the type of speech activity	– lexical trainer – grammar trainer – trainer for improving pronunciation – listening and / or reading
by means and forms of study	– based upon real / educational videos – in the dialogues – by means of exercises – based upon stories – by films – “on the street” – with music

- the illustration of certain aspects of the practical use of commonly used sources of video material in the process of teaching German as the first or second foreign language in a higher school, namely at the pedagogical university;
- the representation of recommendations on the conversion of video hosting content to didactic material while learning Practical Course of German Language by future teacher and the development of educational autonomy of all participants in the educational process.

3 RESEARCH RESULTS

3.1 German Courses on YouTube

The interest of the main German apologists, in particular of the Goethe-Institut (Goethe-Institut, 2021c) and DeutscheWelle (DW) (Deutsche Welle, 2021), to the platform undeniably proves its availability and effectiveness in influencing the process of mastering foreign languages. In the legitimateness of the said, once again the activity of the German international public broadcaster DeutscheWelle convinces of worldwide popularization of German language and the creation and dissemination of the necessary free study programs for its successful completion. Several video playlists that can be used both during class work while learning language and in the process of individual studying, are presented on “Deutschlernen mit der DW” channel. The differentiation of the levels of language proficiency from the “absolute beginner” to C1 / C2 allows the user independently organize his/her work according to the principle “from simple to more difficult”, and the teacher – quickly orientates in the selection of educational material for a particular audience. The length of the video increases gradually, in order not to overload the viewer and maximize the focus on the didactic material of each lesson or series. It is the series, because most of the educational videos are inherently films whose heroes live a particular part of their lives in the German-speaking environment. Heroes, as a rule, are foreigners, and therefore “they look at Germany and German language” through the eyes of YouTube channel viewers.

In addition to the main theme, the mention should be made of the traditional separation in the structure of the speech activity of the four components: speaking and listening (these two types belong to oral speech), writing and reading (written speech). The exams for determining the level of language proficiency, including the "Goethe-Zertifikat", consist of "Lesen" (reading), "Hören" (listening), "Schreiben" (writing) and "Sprechen" (speaking) (oral or individual exam) "Sprechen" (oral or individual exam). Such a division is quite logical, since mastering the native language takes place precisely in this natural scenario: from listening to speaking, reading, and, finally, writing. The practice of working with students, who learn German, shows, that audio competence is the most difficult to formulate. Although at first glance there may be an impression that listening is the easiest for children, without much visible effort, as opposed to writing. However, before starting to pronounce the first words and construct a coherent phrases and sentences, the child for several years is in an absolute linguistic environment where he/she can hear sounds and words of his/her native language, in fact, 24 hours a day. Learning the same foreign language often begins with reading and writing, and then speaking and listening. The perception of speech in real life rarely occurs without visual support, and therefore a significant percentage of information is transmitted by nonverbal means. Involving video materials for listening to music is much more effective than using audio tracks. When a video hero pick up a certain item, naming it at the same time, the need to accompany the introduction of a new lexical unit by the translation disappears. Contemplating certain actions with the subject and listening to the commentary of the heroes, the viewer learns the linguistic roots and grammatical structures.

Of course, it is impossible to make a training video to explain every linguistic phenomenon, so the effectiveness of this learning tool can be greatly enhanced by fixing the new material with additional exercises. Understanding this, the authors of the training series DW offer users to go to interactive tasks at the specified link to the official personal site of the television and radio company. Given the current tendency to reduce the audience load in higher schools of Ukraine and increase the amount of material for independent learning by the student, the use of educational films with exercise complexes can help to optimize their independent work.

YouTube, with its openness to everyone, can be used by teachers as a space for communication. The format of communication in the form of comments is ordinary for modern youth. Free expression of opinions in a foreign language (i.e. speaking) in classes is often hindered by the fear of a public demonstration of an error. Being in a position of assessment by a teacher places the latter in the eyes of the first as a controller, and not as an equal partner in communication.

Offering students the opportunity to discuss certain video materials in comments without mandatory identification of the person, the teacher uses the opportunity to remove excessive nervous tension of the audience and thus intensify the speech activity. Leading a live dialogue requires a quick reaction of the interlocutors, which is difficult to achieve, especially at the initial stage of language learning. In addition, the limited auditorium time does not allow thinking for too long. Pause reduces the dynamics of conversation, thoughts do not find the personification in the right words, the conversation fails, and thus the ability to feel the language as a means of communication loses. A written discussion of a given topic gives an opportunity to think about a replica, to engage in a conversation in a convenient time, to comment on the previously stated statements more reasonably. The tasks performed during the comments may be verified by the teacher (sometimes by the owner of the channel or by other users). If you watch online video tutorials, you can also achieve momentary synchronous interactivity that brings the conversation as close as possible to the "live" one, but this format is more likely to be used for individual work at home, since for class usage this can be technically difficult and organizationally incompatible, with the same schedule.

On the other hand, the teacher's own comments (if necessary also incognito) can promote the unobtrusive orientation of the conversation to a certain didactically determined path, and the usage of correct or contextually relevant linguistic constructions, in response to mistaken or misused, will allow correction of errors without causing a psychological discomfort. Observation of the general course of the conversation may become a valuable source of information for revealing personal qualities, preferences, interests and the level of formation of the foreign language competence of its participants. Such a format of communication may become a kind of modernized Socratic dialogue. It will replace the control by monitoring of the quality of education with the subsequent full realization of all the advantages of the latter for the constant improvement of the educational process.

In addition, participants who are not members of a particular training group may be involved in the conversation, so to speak "strangers". To distinguish them from others in the absence of the desire to register under their own names (at least for the reasons above), you can by agreeing to add a certain code word to the name of the subscriber. The presence of “strangers” opens up good opportunities for the search for “pen-friend”, because among them there are rarely happen to random people. Users from around the world are usually interested in learning German. Focusing on comments, you can choose a potentially interesting and useful for further private communication with the interlocutor. Not only students but also teachers can find for themselves like-minded colleagues in the hosting. Viewers often conduct didactic discussions and share reflections on problems and difficulties related to the learning of German language, especially difficult topics, stylistic nuances, etc.

The occasional cases of participation in commentary discussions on language video teaching media positively motivate those who are only German learners, to search for a tandem partner not only on educational channels. Having a certain passion or hobby and watching videos of relevant subjects in German, where the language ceases are the subject of study and are used exclusively as a means of communication, one can turn to those, who are interested in the common theme of the language and to establish contacts on the appropriate language basis.

Encouraging students or pupils to review not only educational videos but also native speakers’ and various video knowledge departments, you can somewhat make a transition to substantive-linguistic integrated learning in German – CLILIG. Participation in the conference organized by the Goethe-Institute in Kyiv in September, 2017 (Goethe-Institut, 2021a) has become the basis for understanding that learning with the help of the CLIL method allows achieving higher levels of linguistic and substantive competence. The emergence of this methodology has become a response to the needs of the era of technical and digital technologies in specialists of different specialties, which, in addition to specialized knowledge, also speak foreign languages. The combination of professional knowledge, substantive-linguistic and general competences, which is the main goal of CLIL, has become a guarantee of a successful specialist’s career. Numerous reports of conference participants from Germany, Italy, Lithuania and Hungary have revealed the specifics of the usage of the CLIL methodology in the process of learning and the experience of foreign colleagues in integrating foreign language learning with other subjects during school education. Substantially interesting learning motivates learning of German language and creates a linguistic basis, with the help of which it will be possible to build further education, in particular, in a higher school.

The wide theme range of YouTube videos allows you to organize CLIL-based learning not only at school but also in higher school. Implementations of the principle of inter-subject communications are subordinated to the program from all disciplines, regardless of the cycles they belong to. So it only remains to make established communications in foreign languages. We will speculate on the example of students learning German language within the specialty 014.02 Secondary education. Language and literature (German / English) with an additional specialty, accordingly (English / German) language. The main professional disciplines for them are Pedagogics, German and English languages. The vast majority of educational videos, where the German language is the subject of a study as a foreign language, is aimed to the English-speaking audience. They are often accompanied by English subtitles or by the translation of individual lexical units (for example (Learn German, 2017)). The experience of using similar videos in the learning of Practical Course of German as a second foreign language shows a significant increase in students’ interest in learning material, since they are able to orientate on “native” English. The latter in this case ceases to play the role of the direct object of study and becomes a means of learning, although indirectly it continues to study. The topics of practical classes in German and English are often coincided and studied in parallel, so the use of English-German video as a didactic material contributes to improving the quality of knowledge in both disciplines. It also serves as the development of translation skills. At the very least, practice shows that the quality of the implementation of the author’s didactic game “Translator” is significantly increased (according to the rules of the game, one or more participants, performing the role of English speakers, and the other / others German speakers, must be understood on a specific topic, using the participant’s help, who is playing the translator).

A narrowly-focused video may be useful while studying a wide range of topics within practical courses and linguistic studies.

As for Pedagogics and German language, it should be noted that it is not difficult to find videos on the YouTube of a particular topic (for example, the Christian Kißler (Kißler, 2014) channel). However, the question arises - within which discipline is it more appropriate to use them? In our opinion, it is most appropriate to do this at classes on the methodology of teaching a foreign language, since this discipline is taught, as a rule, by a specialist in Pedagogics and the corresponding foreign language simultaneously. Teacher of pedagogical disciplines who does not speak German can find the necessary material in collaboration with his colleagues, and offer students the opportunity to study individually in order to consolidate the knowledge gained during their class work in their native language.

The video format, which is offered by the "LearnGerman" channel, for example (Learn German, 2016), allows you to achieve better results in one more direction of language work. This is a kind of educational activity, such as home or academic reading. Generally, the main goal of individual reading is to develop perceiving skills of written foreign language text, expanding vocabulary and deepening linguistic competence. The accompaniment of audio reproduction of the available for visual perception of the printed source contributes not only to the accompanying development of the above-mentioned listening skills, but also to the improvement of pronunciation. Comparison of the results of text work in two groups of students, one of which used only paper, and the other – audiovisual, showed that the pronunciation, and most importantly intonation, during the retelling of certain passages of the read (and listened) story in the second group significantly improved.

Returning to the institutions that promote German in the world, the Goethe-Institute should be reminded once more and noted that a significant number of its projects on YouTube and not only there is intended to prepare applicants for exams to confirm a certain level of language proficiency. In collaboration with the institute, there are also numerous printed guides from several German publishing houses, mostly accompanied by interactive exercises and audio materials. This logically updates the question of what is and is there in general the prevalence of video channels over "classical", albeit modernized, learning tools. In our opinion, the advantage becomes more obvious, the higher level of language proficiency of the person who prepares for the exam is.

According to (Goethe-Institut, 2021b), having passed the "Goethe-Zertifikat" C1 / C2 exam, you confirm the ability to "understand a wide range of long, rather difficult texts, also capturing the hidden meaning, ... flexible use of language in public and professional life, ... easy understanding of almost everything, read or heard in German". So, in order to confirm the C1 / C2 level it is not enough just to speak correctly and quickly on all well-known topics, but you must be aware of all topics, understand the current trends in the development of science and culture in the world and Germany in particular, and therefore be able to get the latest information about the country. Despite the fact that exam preparation tools are quite often updated, so that available information at the time of the exam may become somewhat obsolete. It's possible to be informed if you read periodicals regularly, listen to radio or watch videos on television or YouTube channels. However, only special videos are accompanied by subtitles or full text, translations, explanations, and exercises that convert them from the usual source of information to the learning tool. The "LearnGerman" channel offers, among other things, German daily news editions, and adapted by subtitles for foreigners videos, which are published several times a day, for example (Learn German, 2021).

The number of educational author channels of various content (from lexical / grammatical explanations and audio exercises to reading / listening to literary texts and preparation for language tests) is constantly increasing. Informal educational videos feature a relaxed atmosphere, relevance, and meta-language reflection opportunity, gaining increasing popularity due to such characteristics. Interested in learning language may choose a teacher not only by the form of teaching didactic material (home videos in the format of communication tete-a-tete or recorded videos), but also by the personal authors' qualities. The latter, in fact, significantly contribute to the promotion of the language and its coverage by a broad audience. It is rarely when a higher schoolteacher may boast thousands of students from around the world who are eagerly awaiting each of his lectures, often defining its topic.

A brief didactical analysis of the general opportunities and practical experience of using the materials of several relevant in the thematic plan channels with a quite wide permanent audience is presented below.

The author of the "Slow German" channel, Anik Rubens, offers users of YouTube audio clips on a wide variety of topics (biographies of prominent German figures, national traditions and customs, domestic issues, social relationships, etc.), dictated at a slow tempo in order to ensure their better understanding. Each lesson is complemented by full written support of the sounded text. Using the Urlaub (Vacation) (Rubens, 2015) material while studying the topic "Travelling" by the Practical Course of German Language (PCGL) program, in combination with self-developed exercises to control understanding showed that the tempo of teaching is optimal for students who speak German at the A2 level / B1, since the vast majority of them understood the general meaning of the heard information after the first listening, and some nuances – after the second or the third.

The "Deutschlernen durch Hören" channel also produces audio tutorials (educational dialogues on various themes, songs) and video materials. In particular, audio texts with control tasks are similar to those used during the "Telc" language exam passing, for example (Learn German Easily, 2020). Doing a trial test on the YouTube platform allows you to feel the atmosphere of a real exam, to assess the difficulty of the task, and to determine the level of your own audio competence by using the correct answer key added to each video. The mentioned above materials may be used as control tasks while the Practical Course of German Language. At the initial stage of learning language, it was quite positive to use a study song which is composed of numerous language cliches typical to the situations "Acquaintance" and "At the cafe / restaurant" (Deutsch lernen durch Hören, 2020).

The real master of the visual-dramatic song, which does not leave anyone indifferent and awakens interest to learn language, is Uwe Kind, the author of the "UweKind & LingoTech" channel, and Singling techniques. Thanks to the amusement, the extraordinariness and, at the same time, the noticeable efficiency of the latter is used by the students and teachers of the whole world in studying spoken foreign languages. In collaboration with composer Mark Schaffel, "LingoTech" was created – "it is a music that combines melody, rhythm, drama, movement and linguistic feedback, becoming a common experience that inspires young people to learn languages." LingoTech is based on the assumption that music simplifies the process of memorization, which allows students to improve foreign pronunciation and intonation (Kind, 2019). It is a song, dance, drama and an interesting way of learning. Due to the understanding interest appears, music (melody) provides the duration of preservation in memory, the dance determines the interaction, and all together contributes to the success of learning. The fact that after the use of the song "Romanze im Perfekt" (Uwe Kind & LingoTech, 2014), students easily memorized three main forms of the irregular Verbs mentioned therein and chanted it on breaks, is an irrefutable proof of the effectiveness of this methodology, the basis of which consists a mnemonic technology based on music and motor activity.

The author of the "Deutsch in Bildern" channel creates his own educational videos using the positive aspects of another mnemonic technique, namely, illustrative. In order to demonstrate the syntactic structure of the sentence and the relationship between its members, there was a train, in which the locomotive is as a Subject, numerous wagons replace the Object, and the Adverbial Modifier is associated with railways (Deutsch in Bildern, 2016). According to the laws of mnemonic, an interesting picture, which will appear before the inner sight in the future, at the right moment will help to find quickly the necessary grammatical material in the long-term memory. The channel is created for native speakers to help them learn German and Literature (as native), Physics, Mathematics and other subjects. For this reason, the tempo of the author's speech is fast enough, which complicates the use of materials (in any case at the initial stage and for self-study). However, the expressiveness of graphic illustrations and the non-standard creative approach to the giving complex teaching material make the channel as a valuable source of positive experience for teachers.

Despite the enormous amount of educational YouTube channels, it is difficult sometimes to find "your own channel" – the one that offers comprehensive, competent answers to relevant issues regarding a wide variety of linguistic aspects and promotes the development of speech and meta-language competencies. Before advising a specific video or channel to students, you should critically treat content, format, and the author's professionalism. Three next channels were created by YouTube bloggers who not only studied German as a specialty for a long time, but also have many years of experience in teaching it.

The "Deutsch mit Marija" channel may be useful, first of all, for those who are preparing to pass a language exam, in particular TELC. The author herself is one of the company's examiners (telc GmbH) (Telc, 2021) and has a great practical experience in pre-test candidate training. A series of videos was created in the form of tips on how to avoid typical mistakes while passing the exam and to what features of each type of task should attention be paid to. At the following links (Dobrovolska, 2016, 2017), for example, we find videos that provide specific recommendations for the successful doing the "Image Description" task. The description skills are necessary for productive communication in real life and are checked not only during the preparation of the above exam. The method of image description is successfully used in Practical classes of a foreign language. In particular, it is the basis for card games that are equally effective at the initial (for the acquisition of the new vocabulary), as well as at subsequent stages of language learning (deploying the speech situation, creating a story / dialogue with the help of the image). Among other things, the author explains what is the difference between doing the "Description" task at the level A1 / A2 and at higher levels, beginning with B / 1; what is the principle of the transfer, according to which the image should be described, in order to demonstrate a good level of language proficiency; how to make the best use of visual information to ensure a productive and informative process of communication; how to make a logical transition from the real image to the situations associated with it, etc. That is why such videos should be used not only while preparing for language tests, but also at Practical Course of German Language as a means of improving communicative competences of students.

In the channel playlists, you can find videos that are dedicated to the enrichment of the vocabulary (Wortschatz). Some of them explain the meaning of constant figures of speech or cliché and contain recommendations on the practicability of using them in speech. Some of them highlight semantic and stylistic features of cognate verbs or nouns. Other video groups are aimed to help you learn grammar and expand your country studying competence. The description of different life situations, seemingly, is devoid of didactic loading, becomes a valuable source of information for those who learn the language in the absence of the possibility of constant communication with its native speakers, who are in modern realities of Germany or another German-speaking country.

Considering information given above, let us note that the author of the next channel has developed a unique method of flooding in a foreign environment. Peter Heinrich, a teacher of German language from Austria, has engaged all his family to create nominal YouTube channel (Heinrich, 2017). Based on the fact that "most of those who learn German have little access to authentic everyday language and culture", over 120 videos were made within the framework of the online family project (ONLINE-Gastfamilie), which show the actual everyday life of an ordinary German family: family holidays, traditions, travelling, problematic home situations, typical working days, etc. Video materials are accompanied by vocabulary, which shows the key communicative structures and reveals important cultural aspects. With a wide range of suggested topics, the training videos can be easily adapted to the tasks of the curriculum of Practical Course of German Language. However, the situation may be somewhat complicated by the fact that not all videos and teaching materials are available on YouTube, but there are more than enough to "catapult your German language from theoretical grammar to active understanding and speaking and make a leap into German culture" (Heinrich, 2021).

Among the positive achievements of the German-Skills.com channel, it has to be noted the provided methodological recommendations for the development of pronunciation skills. The proposed exercises, for example (Dilyana, 2017), brought tangible results in the formation of the correct articulation of one of the most difficult sounds in German language for Ukrainian students, – pronounced in the French manner [r].

The practical application for materials, which appears within the framework of 30 Days Challenge, has also been found at Practical Course of German Language lessons. 30 TageChallenge is dedicated to the problems of learning German language: how to speak correctly and quickly, how to use multimedia to learn language, how to master different types of speech activity, how to avoid mistakes while learning new vocabulary, why there is a fear of speaking in foreign languages, etc. (Dilyana, 2018). Students were asked to register as the project participant and to join a peculiar thirty-day marathon. Depending on the level of language proficiency, the participants received an e-mail daily task – the theme of the day from which they had to speak by recording an audio message. The predicted audio format of the answer helped many to overcome the fear of speaking aloud, and the ability to listen to the messages of other participants and discuss them contributed to the activation of speech skills. Several reports by the author of the channel on the issues of challenge were offered for individual extra-audition listening to students who did not join the experiment, which caused an active reflection of the latter.

3.2 Use of Alternative YouTube Resources for Teaching and Learning German

Distance learning as a form of organization of the educational process is extremely relevant during quarantine activities. Most educational institutions have switched to online mode and use various resources to do so, which allow both synchronous and asynchronous communication with their students. The use of such resources in independent work is especially effective, because it allows to satisfy the interests of students (they choose the time, the forms, the materials that are convenient and interesting to them), on the one hand, and fill the educational space with educational materials. which are diverse in nature, sometimes offer alternative views on the problem and encourage its critical reflection with the subsequent formation of their own opinion, on the other.

One of such resources is YouTube channels, because they offer not only purely educational materials for learning German (or another foreign language, because these platforms also offer materials for learning other foreign languages), which was analyzed in the previous section, but directly are related to various disciplines in both general and higher education. Obviously, YouTube uploads and stores materials that, regardless of their purpose at the time of creation and placement on the platform, can be used to teach foreign languages, if they are properly prepared.

All these materials can be divided into several groups: materials that include educational content

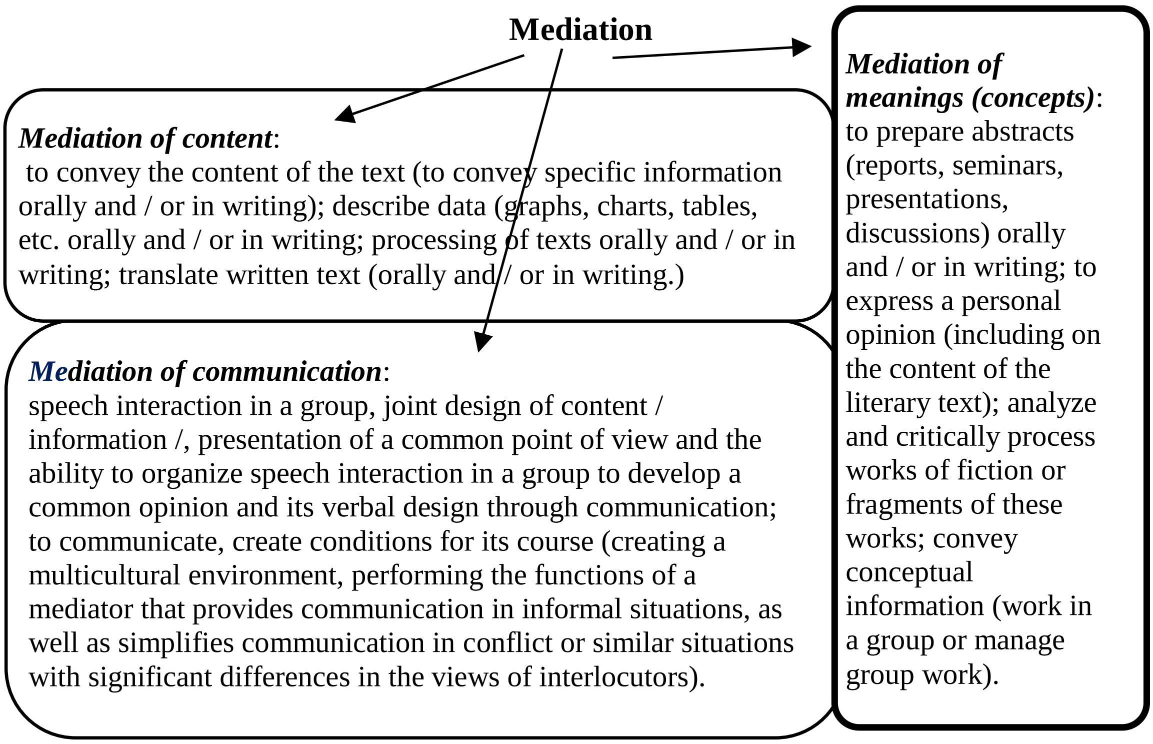

Figure 1: Three aspects of concept of "mediation" and their main activities (Council of Europe, 2018, pp. 109–123).

of different disciplines (geography, biology, physics, history, literature, etc.); informational videos and blogs about interesting facts, events, regions, prominent people, politicians, other information, mainly of an advertising nature; documentaries, popular science short and feature films; feature films and TV series on various topics.

One of the positives of this kind of material is that YouTube presents materials from all 4 groups in several languages, so the content is multilingual and allows you to work with sources that cover the same issue in different languages. This possibility is especially relevant in light of Companion Volume of the Common European Reference for Languages, where mediation is considered as one of the competencies with an appropriate description for each level of language proficiency from pre-A1 to C1. This concept was introduced by authors of Common European Framework of reference for language: learning, teaching and assessment in 2.1.3 – Language activities we can read the folowing: "The language learner/user's communicative language competence is activated in the performance of the various language activities, involving reception, production, interaction or mediation (in particular interpreting or translating). Each of these types of activity is possible in relation to texts in oral or written form, or both" (Council of Europe, 2001, p. 23). Mediation is one of the types of interaction and cannot be limited only to it, and therefore further in the text the authors specify their understanding of mediation, but through "mediative types" of speech activity, which "make communication possible between persons who are unable, for whatever reason, to communicate with each other directly" (Council of Europe, 2001, p. 23). These include: translation or interpretation, a paraphrase, summary or record, (re)formulation of a source text.

In addition, paragraph 4.4.4 Communicative and languages activities and strategies take into account the communicative actions that fall under the interpretation of "mediation", because among the examples of mediation activities, the authors call primarily oral and written translation, abstracting and translation of texts in a language understandable to the third speaker. It is emphasized that in mediation the speaker do not express his / her own thoughts but "is acting as a channel of communication (often, but not necessarily, in different languages) between two or more persons who for one reason or another cannot communicate directly" (Council of Europe, 2001, p. 66).

In fact, CEFR understands mediation as translation, as evidenced by explanations of oral (simultaneous, consecutive, informal translation) and written (exact (contracts, agreements), literary (works), transfer of the main content (newspaper, magazine articles), translation (specialized texts for non-professionals) mediation (Council of Europe, 2001, p. 66).

The modern version of CEFR Companion Volume with New Descriptors (Hirsch, 2018a) uses the term "mediation", which is much broader in scope, as it is not limited to the translation and transmission of the main content without taking into account the opinion of the user who performs mediation, but includes those communicative activities that were not considered before. "In mediation, the user/learner acts as a social agent who creates bridges and helps to construct or convey meaning, sometimes within the same language, sometimes from one language to another (cross-linguistic mediation).

The focus is on the role of language in processes like creating the space and conditions for communicating and/or learning, collaborating to construct new meaning, encouraging others to construct or understand new meaning, and passing on new information in an appropriate form. The context can be social, pedagogic, cultural, linguistic or professional" (Council of Europe, 2018, p. 103). The Companion Volume considers at least three aspects of the concept of "mediation" as a descriptor and the main activities, which are described in CEFR 2018 and shown at figure 1.

These actions can be developed by the use of existing YouTube content.

We will analyze the available context of resources posted on YouTube, that can be used in the process of teaching German (as the first and/or the second language) for future teachers. We consider it advisable to observe resources according to the nature of the offered material, after all it is decisive at the didactic stage.

The first group includes educational materials that are not directly related to foreign language teaching, but contain information related to those topics that are included in the program and are studied in practical German course as the first or the second language, or reveal the content of particular modules or blocks of other disciplines of the educational program, such as the history of the German language, literature, stylistics or intercultural communication. The vast majority of such materials are video clips from 3 to 15 minutes, that offer basic information about the essence of concepts, their key features, peculiarities, differences from other similar phenomena and more in an accessible and understandable form. Such information is provided in the form of a lecture given by a teacher, a presentation voiced by a moderator, a story accompanied by fragments of animated or documentary films, comments of a schematic representation of processes, and so on. We consider it possible to illustrate different approaches to the presentation of educational content on the example of the course "History of German Literature", namely the theme "Baroque", because this literary era has certain features in the European context.

The second group includes informational videos and blogs about interesting facts, events, regions, outstanding people, politicians, that contain other information, often of advertising nature. This content is not educational but can be used in the educational process for different educational purposes and in different ways. The main advantage of such content is that firstly, the duration of video clips is up to 10-15 minutes and commercials last from 1 to 3 minutes; they contain condensed information that is easy to remember because it is supported by graphic images; the same information can be offered in different languages, that encourages the implementation of mediation. The use of such material is especially effective when design work is being done. For example, within the framework of the project "Deutsche Spuren in der Ukraine" students were asked to do a number of tasks using the YouTube resource, the fragment of one of them is offered below.

The third group includes popular science, documentary short or full-length films that are not designed for a specific target group and contain general information. They can be used first of all for the development of receptive competencies, checking the understanding of what is heard, systematization of the received information, its further consolidation and presentation through the target language. Films of the ZDF channel "Die Deutschen" 1 and 2 are extremely interesting, they tell about outstanding people in the context of German history from the Middle Ages to the Present (https://www.youtube.com/watch?v=F1t6-UyHV8U&list=PLtkAitkGhcGLS1y1xPdxGzBUE45ico2zY); "Wir Europäer", (https://www.youtube.com/watch?v=dax4xCtxPd0&t=71s), which deals with the history of Europeans; films about culture, life, problems, landscapes, historical monuments, etc.

The fourth group includes feature films and TV series which can be used as a means of developing of both receptive and communicative skills, a source of local lore information because heroes of any film live in conditions close to reality that gives an idea of German lifestyle.

Arbeitsblatt 8

Aufgabe 1. Sehen sie sich den Kurzfilm über das Leben der Deutschen in Transkarpatien: https://www.youtube.com/watch?v=OarTBeBi1DI

Während des Sehens notieren Sie sich Informationen, die Sie brauchen, um die Fragen zu beantworten.

1. Wie kamen die Deutschen nach Transkarpatien?
2. Wie leben die Deutschen in Transkarpatien? Haben Sie ihre Organisationen? Womit beschäftigen sie sich?
3. Gibt es Probleme in der Kommunikation mit den Ukrainern?
4. Woher kamen die Deutschen nach Swalawa?
5. Was hat Herr Kmeti über seine Familie erzählt?
6. Was hat Herr Zwanko über die Gruppe "Schwalbach" erzählt?
7. Haben die Deutschen Kontakte zu deutschen Firmen, Organisationen? Welche Projekte werden realisiert?
8. Deutsche Bäckerei in einem ukrainischen Dorf. Erzählen Sie darüber.
9. Wie fühlen sich die Deutschen in der Ukraine? Was hat Julia erzählt?

Mehr Informationen finden Sie hier: https://ukrainer.net/nmtsi-ukrainy/

Aufgabe 2. *Deutsche Unternehmer versuchen in der Ukraine ihr Glück. Sehen Sie sich den Kurzfilm mit dem deutschen Unternehmer und geben Sie den Inhalt wieder: https://www.youtube.com/watch?v=G4oRsnyc8D4&t=155s*

Was lockt die Deutschen an? Haben Sie Probleme? Womit? Oder mit wem? Sind die Arbeiter der deutschen Unternehmen in der Ukraine mit ihrer Arbeit zufrieden?

Aufgabe 3. *Schlechte Erfahrung mit der Ukraine. Der Film aus dem Jahr 2014. Sehen Sie den Film und notieren Sie sich Probleme und Schwierigkeiten, die bei den Unternehmern und Firmen auftreten. Was kann man dagegen tun? https://www.youtube.com/watch?v=Tf7vqeAlRwU*

Aufgabe 4. *Lesen Sie die Beschreibung des Filmes und dann sehen Sie sich den Kurzfilm an: https://www.youtube.com/watch?v=9i2M7M5K49Q&t=112s*

The right choice of material and effective approaches to the use of each case of didactic approaches are the key components in work with YouTube videos.

3.3 Tools for Developing Educational Autonomy on YouTube Channel

The use of the content of the above-listed channels contributes to the acquisition of professionally significant knowledge and the formation of the necessary skills for the success of a teacher as a specialist in the labour market. However, current trends in society set new demands for the system of professional training of foreign language teachers. The qualification of a specialist and his/her demand is also currently determined by the level of his/her readiness for further independent professional development and self-improvement and by the formation of educational competence or autonomy in education.

Autonomy is a component of qualification levels in the National and European Qualifications Framework along with knowledge, skills and competences and is defined as the ability to act independently within one's professional competences. Gaining a certain learning autonomy in language learning will allow developing an individual work schedule according to one's learning type, to set educational tasks following one's own goal, to choose the forms and methods of language learning that are the most effective to achieve this goal.

The project ONCOO, designed by Olaf Müller and Thomas Rohde, provides extensive opportunities for the development of educational autonomy (www.ebildungslabor.de, 2018). The tools, that are used on this platform, provide support for both classroom and extracurricular cooperative forms of learning. Cooperative methods are useful at different stages of classes (introductory, main, at the stage of delving into the topic, for reflection and evaluation) and can be used for both beginners and students with good language skills. The tool is easy to use: it does not require registration and entering personal data. A teacher provides access to the worksheet by sending students an access code. ONCOO generally offers five tools to organize the learning process more efficiently and interestingly (figure 2).

Card survey (Kartenabfrage): a teacher initiates a survey on a virtual board, students create message cards and attach them to the virtual board. These cards can be sorted and structured using special tools that are located in the active window in the process of further group work.

Assistant system (Helfer-system): this tool has the

Table 2: “Barock in der deutschen Literaturgeschichte” on YouTube.

A lecture given by a teacher	Barock kurz und einfach erklärt I musstewissen Deutsch A2 Literatur des Barock - Barocke Lyrik	https://www.youtube.com/watch?v=f-75XBb2ZiI https://www.youtube.com/watch?v=wnri4WHOpdg
A presentation voiced by a moderator	Barock - Literaturepoche einfach erklärt - Merkmale, Literatur, Geschichte, Vertreter; A4 Literatur des Barock - Barocke Romane	https://www.youtube.com/watch?v=Khpxmxy37mQ, https://www.youtube.com/watch?v=QNROLtbE6LQ, https://www.youtube.com/watch?v=735QsJh-znw
A story accompanied by fragments of animated or documentary films	Wallenstein und der Krieg - Die Deutschen (Staffel 1) - ZDF	https://www.youtube.com/watch?v=za1gJdLzba8
Comments of a schematic representation of processes	Epoche des Barock - (studentische) Einführung — DiB	https://www.youtube.com/watch?v=Fc2VgMyyCuE&list=PLAtaQ-5u2Yrhf75wbrFIY_bM4V4ikonPu&index=2
Full-length educational, documentary or feature film	Johann Grimmelshausen Abenteuerlicher Simplizissimus	https://www.youtube.com/watch?v=L8020Ls8b_Q

form of a namelist involving all the students according to their status (”a participant” or “an assistant”), it helps to create atmosphere of competition and to develop the participants’ responsibility for their own and partners’ achievements. Using the tool “participants” report that they have coped with their own task and in the following stage they begin to act as “a helper” for those who need support and assistance. Thus, those participants who have difficulty completing the task may ask “helpers” for help.

Training tempo-duet (Lerntempoduett): a teacher can effectively manage individual work and work in pairs: students begin to work individually and report with the help of this tool on the readiness to check the task, a teacher divides students into pairs for further processing of the task and its checking.

Placemat is used to support individual work of students and allows a smooth transition to group discussion. ONCOO makes it possible to set the timing for the first phase (thinking and solving a crossword puzzle): firstly, students give answers individually and a teacher can make them available to all other group members at his/her own discretion. Secondly, there is a search for a common solution in the process of group discussion).

Target (Zielscheibe) creates an opportunity to conduct a joint evaluation and reflection on the work done. With the help of this tool, a virtual target is created, which presents various aspects of assessment, and students make their assessments individually using a virtual dart.

The web tool Twine (webtool) is available on YouTube and can be useful for the development of future teachers autonomy in education (ebildungslabor.de, 2021; DigitalExposureTV, 2017).

It is designed to create interactive texts and can be used both by teachers to create textbooks – tutorials and other materials for independent work, and by students to develop their methodological competence, developing their own learning materials: games, creative interactive stories, etc. If you want to create your own interactive story (Twine) or hypertext you need to go through a few simple procedures: add individual snippets of history, connect them using links, select “stylesheet” in the menu and design appearance of the story with available options, choose the menu “als Datei veröffentlichen”, download and share with the group. You can send this file by email or any messenger. Stories are designed in such a way that a reader must choose from the text one of several options for the development of events, creating from the proposed material his/her own story. In this way, a teacher gets an opportunity to conduct a group discussion after a stage of individual work, and to encourage students to actively cooperate, comparing different versions of stories.

H5P is an interesting, useful and at the same time accessible of all types of devices (computers, tablets, smartphones) for creating interactive educational content. Content can be created directly in the browser. It is effortless to work with this tool,and it does not require special skills in working with ICT. A large amount of different content is available on H5P (H5P, 2021) page:

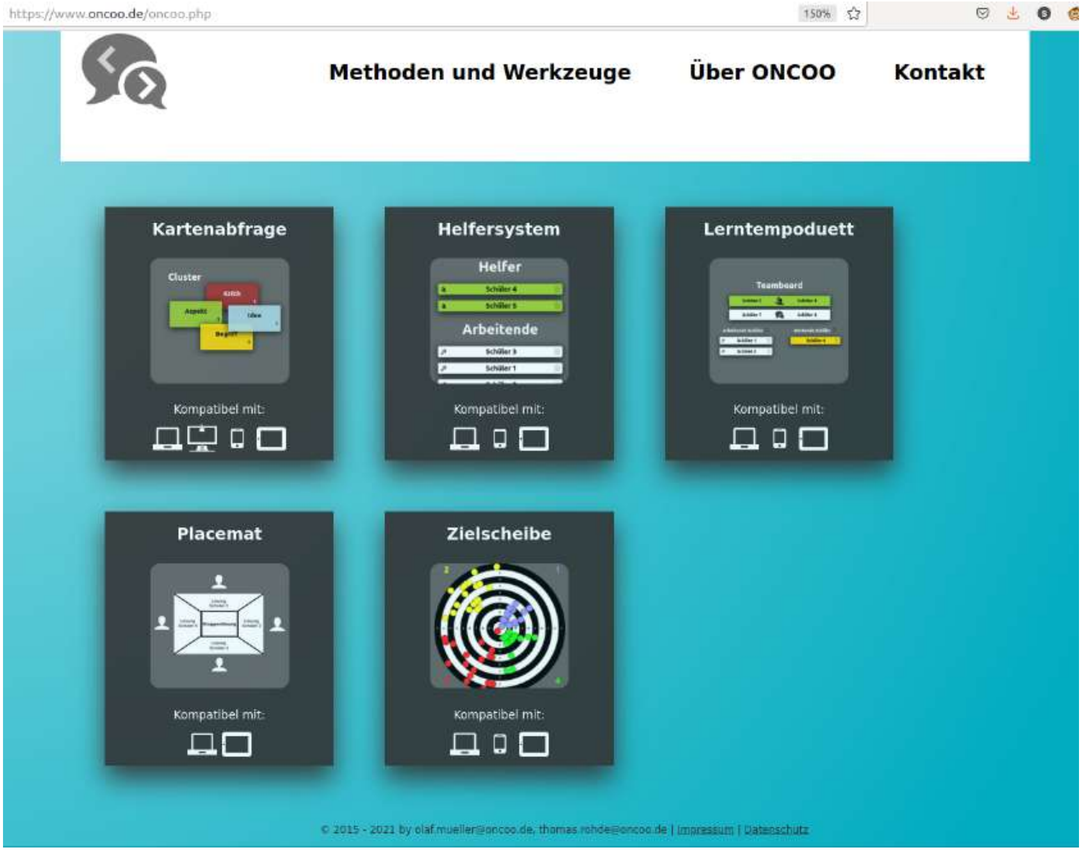

Figure 2: ONCOO tools (Hirsch, 2018a).

- Audio Recorder (for creating an audio recording);
- Advent Calendar (for creating an advent calendar);
- Dialog Cards (for creating text-based turning cards);
- Dictation (for creating a dictation with instant feed-back);
- Essay (for creating an essay with instant feed-back) and many others.

Consider as an example Advent Calendar: a teacher independently fills the calendar with pictures, links, videos, texts focusing on the objectives of his/her training course. There are videos on YouTube that guide teachers on the methodological principles of using such tools and creating their own modern interesting and motivating learning material (Hirsch, 2018b, 2020).

Specialized publishers of educational and methodical literature, which organize methodical webinars, also help teachers to develop independently their methodological competence and improve professionally. Online webinars later become public on YouTube. For example, the well-known publishing house Klett publishes numerous digital learning webinars, reviews of textbooks with guidelines for their use and much more on its channel (Pearson Turkey, 2020).

Support for online classes is offered by the YouTube channel Future-Teach (Future-Teach, 2020). There are practical tips for using Microsoft Teams für Office 365 for educational purposes, tips for creating online surveys and quizzes, using various digital Apps and Tools, Skype and Zoom – conferences that promote the educational students' autonomy and methodological competence of (future) teachers.

4 CONCLUSIONS AND PERSPECTIVES FOR FURTHER STUDIES

We should note that the author's training channels on YouTube from professional vendors and amateurs can be used as additional teaching material in class and extracurricular for those students, who learn German language. There is obvious positive impact on:

Table 3: Content characteristics and some recommendations toward using YouTube channels.

Channel / Level	**Kind of educational material**	**Subject / additional information**	**Resource**	**Scope of use**
Deutsche Welle / A1 – C1	video clips	casual situations, intercultural differences	interactive tasks, forum	classwork, homework
Learn German / A1 – C1	video clips	various subjects, news of culture and science	subtitles in English, full text, exercises, explanations	home reading
Slow German / A1 – B1	audio	everyday situations, social problems, country studies	full text, slow speech	classwork, homework, listening
Deutsch lernen durch hören / A1 – C1	training dialogs, video clips, songs	everyday topics, country studies	exam format, task, keys	classwork, homework
Deutsch mit Marija / A1 – C1	video clips	everyday topics, country studies	tasks, grammar- and vocabulary-training	classwork, homework
Materials with learning content	video	various subjects, news of culture and science	information to various subjects; *tasks to be prepared*	homework, project
Informational videos and blogs about interesting facts, events, regions, prominent people, politicians, other information, mainly of an advertising nature	video	various subjects, news of culture and science; casual situations, intercultural differences, country studies	general information to various subjects; *tasks to be prepared*	homework, project
Documentaries, popular science short and feature films	video	various subjects, news of culture and science; intercultural differences, country studies	general or specific information to various subjects; *tasks to be prepared*	homework, project
Feature films and TV series on various topics	video	casual situations, intercultural differences, country studies	features of everyday life, country studies; *tasks to be prepared*	homework, project

- creating a dynamic learning environment;
- increasing the motivation of students' educational and cognitive activity by flooding into the linguistic environment through authentic video materials;
- optimization of individual work aimed at deepening or strengthening knowledge on specific educational topics, on condition of availability of professional monitoring and control.

The use of information technologies creates additional opportunities for teachers, but requires a responsible approach to their use in order to achieve the goals and objectives provided by the curriculum. Integration of open sources of information into the educational process in higher schools requires careful selection of available material and its creative didactical revision (in particular, supplementation with the training activities agreed upon the purpose of concrete practical training). However, the question remains open of the probability of achieving a certain level of language proficiency solely on their basis. The latter requires a particular scientific research.

Content characteristics and some tips for using YouTube channels are summarized in table 3.

Expanding the boundaries of educational videos usage, which are represented as additional tools for teaching foreign languages provided in video hosting, on condition that they would be pre-adapted to the requirements of educational programs, has no doubt. The possibilities of developing certain competencies by using the above-mentioned YouTube channels are represented in the table 4.

Hence it seems expedient to master the methodical techniques of introducing them into the process of higher schools training of students of pedagogical specialties and encouraging the latter to create their own educational videos that are suitable for work in the audience and outside it.

Table 4: The logical framework for the development of linguistic and general competences by using YouTube channels.

Channel / Level	**speaking competence**	**listening competence**	**reading competence**	**writing competence**	**cross-cultural competence**	**methodical competence**	**learning autonomy**	**general competences**
Deutsche Welle / A1 – C1		*	*		*		*	*
Learn German / A1 – C1	*	*	*	*			*	*
Slow German / A1 – B1		*	*		*		*	*
Deutsch lernen durch hören / A1 – C1		*					*	*
Deutsch mit Marija / A1 – C1	*	*	*	*			*	*
Informational videos and blogs	*	*		*	*		*	*
Documentaries, popular science short and feature films		*			*		*	*
Feature films and TV series on various topics	*	*			*		*	*
ONCOO	*		*	*		*	*	*
Twine	*		*	*		*	*	*
H5P	*	*	*	*		*	*	*
Future-Teach		*				*	*	*

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Ontological Approach to the Presentation of the Subject Area of the Discipline

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Keywords: Ontological Approach, Computer Ontology, Knowledge Representation, Computer Ontology Design Algorithm, Educational Discipline, Subject Field.

Abstract: The article considers the problem of methodology of designing computer ontology of the subject area of the discipline by future specialists in the field of digital technologies. The scheme of ontology of the subject discipline is presented in which the set of concepts of the future computer ontology and the set of relations between them are represented. The main criteria of the choice of systems of computer ontologies for designing computer ontology of the subject discipline: software architecture and tools development; interoperability; intuitive interface are established. The selection of ontology design methods by means of computer ontology systems has been specified. An algorithm for designing a computer ontology of the subject area of the discipline by future specialists in the field of digital technologies is proposed. The effectiveness of the proposed scheme of ontology of the subject area of the discipline and the proposed method of technology has been investigated experimentally on three indicators: 1) the speed of construction of ontologies; 2) the number of defects; 3) the speed of addition of already created ontologies.

1 INTRODUCTION

One of the important trends in the development of modern computer systems is ontologically managed information systems. The construction of the latter is closely connected with the development of theoretical foundations and design methodologies including a formalized approach, fundamental principles and mechanisms, generalized architecture and structure of the system, a formal model and methodology for designing ontology of the subject field (including ontologies of educational disciplines), formal model of presentation of knowledge, generalized algorithms of procedures for knowledge processing, etc. Accordingly, each of the listed components of the general design methodology is a complex information-algorithmic structure and falls within the scope of future specialists in the field of digital technologies. Comprehensive solution of these tasks of design will provide an opportunity to enhance the role of ontological (conceptual) knowledge in solving concrete problems in applied branches in general and in the educational process in particular (Dovhyi et al., 2013, p. 9).

Ontologies are a promising technology for the development of modern educational systems. Representing the basic concepts of the subject area in a format available for automated processing in the form of a hierarchy of classes and relationships between them, ontologies allow for automated processing of the semantics of information units.

Depending on the approach used in modeling subject knowledge (thematic, functional, procedural, operational or semantic), there are different methods of

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structuring information concepts of the subject area (Gruber, 1995, p. 911): semantic networks, lattice theory, operations on graphs, genetic algorithms, neural networks, ontologies and other mathematical models.

However, the process of designing computer ontologies is complex and lengthy and requires knowledge of many declarative languages, and in order to facilitate it, there is a need for the use of certain systems created to design computer ontologies that provide such interfaces that allow them to conceptualize, implement, verify inconsistency and documentation. In recent years the number of tools for working with computer ontologies has increased dramatically (more than 50 editing tools). However, most of these tools are intended to use existing ontologies by the help of formal languages, such as: Common logic; Cyc; Gellish; IDEF5; KIF; Rule Interchange Format (RIF) and F-Logic; OWL; XBRL (Ovdei and Proskudina, 2004). Therefore, in the process of training future professionals in the field of digital technology, there is a need to use these systems for designing computer ontologies that could provide interfaces that would allow operations to be carried out in connection with the formal representation of sets of concepts and relationships between them. Computer system ontology (CSO) are a certain answer to this need, especially in the context of designing a computer ontology of the subject area of the discipline by future specialists in the field of digital technologies.

The process of developing and using ontology in general form is considered by Noy and McGuinness (Noy and McGuinness, 2001), Nirenburg and Raskin (Nirenburg and Raskin, 2004). Problems of ontologies and their use in computer systems were considered by Lapshyn (Lapshyn, 2010). The discovery of the meaning of the concept of "ontology", given to it in the computer sciences, the works of Gruber (Gruber, 1991, 2008, 2007, 2006, 2003, 1993; Gruber et al., 1996) and others are devoted to it. Some aspects of the use of computer ontologies, in the context of intellectual technologies, are discussed in (Spirin, 2004; Lytvyn et al., 2013; Tsidylo, 2014). An overview of the instruments of ontology engineering was done by Ovdei and Proskudina (Ovdei and Proskudina, 2004). Methods for creating an interface based on ontology in the environment of the web portal were studied by Popova and Stryzhak (Popova and Stryzhak, 2013), Stryzhak (Stryzhak, 2016). The modeling of the ontology of the educational subject field as a means of integrating knowledge was studied by Yevseeva (Yevseeva, 2009), Liubchenko (Liubchenko, 2008), Stryzhak et al. (Stryzhak et al., 2014) and others. Modeling the categorical level of the language-ontological picture of the world was done by Palahin and Petrenko (Palahin and Petrenko, 2006). Ontological representation of decision-making processes was done by Chaplinskyi (Chaplinskyi, 2009). Using the ontology of the subject area to eliminate ambiguities in the computer translation of technical texts was proposed by Morentsova (Morentsova, 2018). The works of the above-mentioned authors contributed to the accumulation and systematization of knowledge for improving the practical training of students on the creation and use of computer ontology. However, they do not sufficiently disclose the peculiarities of training to create an ontology of a particular subject area in the training of future professionals in the field of digital technologies, taking into account their professional engineering and professional pedagogical activities.

The *purpose* of the article is to substantiate the ontological approach of presenting the subject area of the discipline as a means and result of systematization of knowledge of future specialists in the field of digital technologies.

2 RESULTS

In the process of training specialists in the field of digital technologies at higher educational institutions, the study of intelligent systems, in which ontologies are used for the formal specification of concepts and connections inherent in a certain field of knowledge, occupies a significant place. Since the computer cannot understand how a person does, the state of things in the world, it must be submitted with all the information in a formal way. Consequently, ontologies serve as a kind of model of the surrounding world, and their structure is such that it is easily subjected to machining and analysis. Ontologies provide the system with information about well-described semantics of given words and indicate the hierarchical structure of the medium and the relationship of the elements. All of this allows computer programs to draw conclusions from available information and manipulate those using ontologies.

Hence, it is Gruber (Gruber, 1991) who authored the concept of "ontology" in engineering. The task of constructing a description of knowledge is very specific. Therefore, Gruber (Gruber, 1991) has identified a specific term for this task – the "specification of conceptualization". Under "conceptualization," he understood "an abstract, simplified view of the world, which is used by people to realize a certain goal" (Gruber, 1991, p. 602). The peculiarity of the task of conceptualization lies in the fact that for the exchange of knowledge between software systems (in the context of the concept of artificial intelligence), it is necessary to openly specify their conceptualization, that is to build a description of this knowledge, moreover, sufficiently formal, that it was "understood" by other systems.

In the process of developing intelligent systems, the most time-consuming are the stages of conceptualization and formalization, which are considered in work (Buyak et al., 2018) in the process of designing a structural model of a neuro-fuzzy expert decision-making system for determining the professional selection of students for the training of IT specialties.

More specifically, the concept of ontology is defined by Faure et al. (Faure et al., 1998), who assumes that ontology is an explicit specification of a particular topic.

Therefore, the ontological approach allows a formal and declarative presentation of a topic covering a dictionary (or list of constants) to refer to the terms of a particular subject area, limiting the integrity of these terms or logical statements that limit the interpretation of terms and how they are combined with each other.

Thus, ontology defines a general terminology for scholars who need to share information in a particular subject area. It covers suitable for interpretation by means of a computer definition of the main concepts of the subject field and the interconnection between them. With the increasing popularity of usage of computer ontologies, their study should be included in the curricula of the higher educational institutions, since they can generate test tasks, create didactic materials from different disciplines and branches of knowledge, etc.

However, as mentioned above, the process of designing computer ontologies is complex and time-consuming and requires knowledge of many declarative languages, so in the activities of future professionals in the field of digital technologies it is more appropriate to use CSO that are a computer program or software package that intended for the construction of computer ontology from a certain subject field and perform operations related to the formal representation of sets of concepts and relationships between them, in addition, computer ontologies can be exported to a variety of formats, including invoking RDF (RDF Schema), OWL and XML Schema, etc.

Regarding the choice of a specific CSO, it should be implemented according to some of the following criteria: 1) software architecture and development of tools containing information about the necessary platforms for using the tool; 2) functional compatibility, which includes information on tools and interaction with other languages and tools for the development of ontologies, translation from some languages ontologies; 3) the intuition of the interface, covering the work with graphic editors, the co-operation of several users and the need to provide multiple use of ontology libraries (Kozibroda, 2016, p. 179).

However, to build a computer ontology of the subject area of the discipline, future professionals in the field of digital technology must also reflect the content of the subject area of the discipline, which is described as a list of modules implemented in various forms of classes in a particular discipline. At the same time, relevant competencies for each module are indicated besides the content, form and control, and their extent. Based on the analysis of the subjects and objects of the learning process, the processes of creating and managing the educational material, one can identify the following problems that arise during the development of the training course:

- high complexity of the process of finding new teaching materials;
- the need to assess the conformity of educational resources with the requirements of the content of the training course;
- providing educational resources with the full coverage of the modules of the discipline in general and the course in particular;
- excessive coverage of the modules of the discipline and implementation of the choice of the most optimal educational resource for a particular situation;
- the need to assess the quality of educational resources.

Thus, in the process of developing content modules of the discipline it is important to identify certain requirements for the model of presentation of knowledge and data on the basis of a systematic analysis of the specifics of the subject area, proposed by (Anikin, 2014, p. 62).

To implement a model of presentation of knowledge and data that meet the requirements considered, it is expedient to use an ontological model of presentation of knowledge, which combines the properties and advantages of other models of presentation of knowledge and data (graph model, tree-based model, relational model, semantic network, framing, logical model, etc.).

Solving the tasks of the search and integration of educational material in the personalized educational collection can be realized in the ontological model because of the development and inclusion of the corresponding semantic rules in computer ontology.

The formal model of ontology can be represented as:

$$O = <C, R, F>,$$

where C – the final set of concepts of the subject field, which determines the ontology of O; R – the final set of relations between them; F is the final set of functions of interpretation given on the concepts and/or ontology relations of O.

The restrictions imposed on the set C are not infinity and are not empty ($C \neq \emptyset$). The sets R and F can be empty, which corresponds to certain types of ontology, when it degenerates into a simple dictionary ($R = \emptyset$, $F = \emptyset$), taxonomy of concepts ($F = \emptyset$), etc.

One of the possible ontological bases for the description of computer ontologies in the context of the use of computer ontology systems by future specialists in the field of digital technologies, presented in (Pikuliak, 2014, p. 197), are: lasses united in taxonomy; relationship (type of links between concepts of the subject industry); functions (a special kind of relationship in which the n-th element of the relationship is determined by the values of $n-1$ of the preceding elements); axioms (simulate offers that are always true); specimens (entities) that make up specific objects of the real or abstract world.

OWL-DL combines OWL expressiveness and completeness of computations (all logical conclusions performed on an ontology basis will be thoroughly calculated) and extensibility (all calculations are completed at a certain time). The OWL-DL contains all OWL language constructs that are subject to certain restrictions (for example, a class may be a subclass of many classes, but cannot be a representative of another class).

Accordingly, the ontological model of the subject discipline of the discipline ODD (figure 1) will be defined as:

$$ODD = <CDD, InstDD, RDD, IDD>,$$

where CDD is the final set of concepts for the ontology of the core curriculum knowledge (CDD = {cDD1, cDD2, cDD3, cDD4, cDD5, cDD6, cDD7, cDD8, cDD9, cDD10, cDD11, cDD12}; cDD1 – the DataDomain class for the definition of the subject discipline; cDD2 – is the Competence class for identifying competences in a learning discipline; cDD3 is a Concept class for defining the concepts (terms) of a discipline subject field that is a subclass of cDD2; cDD4 is a UCompetence class for identifying universal competencies; cDD5 is a class of PCompetence for defining professional competencies; cDD6 – ZNKCompetence class for general knowledge competencies; cDD7 – ICompetence class tool for determining competence; cDD8 – SOKCompetence class for the definition of social / personal / general cultural competencies; cDD9 – is the Skill class for determining the skills obtained in the subject discipline, which is a subclass of cDD2; cDD10 is the Ability class for determining the skills obtained in the subject field of the discipline, which is a subclass of cDD2; cDD11 is a Language class that defines the language of presentation of information in the discipline subject field; cDD12 – Complexity class to determine the level of development of competencies of the discipline);

InstDD – is the set of competencies, concepts of the subject discipline, as well as the skills represented in the natural language of instances of classes CDD; InstDD = {iDD1, iDD2, ... iDDm, ... iDDn};

RDD – the final set of relations of the ontology of the knowledge base of the discipline; (RDD = {rDD1, rDD2, rDD3, rDD4, rDD5, rDD6, rDD7, rDD8, rDD9}; rDD1 – hasLanguage ratio, rDD2 – hasComplexity ratio, rDD3 – includes ratio, rDD4 – hasHierarchicalRelation ratio, rDD5 – dependsOn ratio, rDD6 – isSynonym ratio, rDD7 is the ratio is, rDD8 – hasTitle, the ratio rDD9 – hasCompetence);

IDD is the set of interpretation rules, $IDD = \emptyset$.

The set of concepts for the CDD ontology of the knowledge base of the discipline is presented in table 1, and the set of RDD relationships is in table 2. The defining areas and the domains of relationship values can be both defined concepts and their daughter concepts within the framework of the ontology. Based on the plurality of these concepts and the relationship between them using the CSO, future teachers-engineers will be able to conduct ontological design of the subject field of the discipline they need.

However, the question of how to design a computer ontology remains open. Currently, there are several methods of constructing ontologies and they are all based on the principles proposed in (Gruber, 1995, p. 918): 1) Clarity. The ontology must effectively convey the meaning of terms; 2) Compatibility. The ontology must be compatible, i.e. the conclusions that can be drawn from the definitions of concepts and the relationships between them must be compatible with the original terms; 3) Extendibility. The ontology should be constructed so that it can be used effortlessly in separate ontology libraries; 4) Minimal encoding bias. The designed conceptual scheme should not depend on the specific language used to write the formalized description; 5) Minimal ontological commitment. The ontology should contain as few facts as possible about the ontology of the world being modeled, while giving the freedom to use this ontology in other worlds.

However, in the context of designing a computer ontology of the subject area of the discipline on

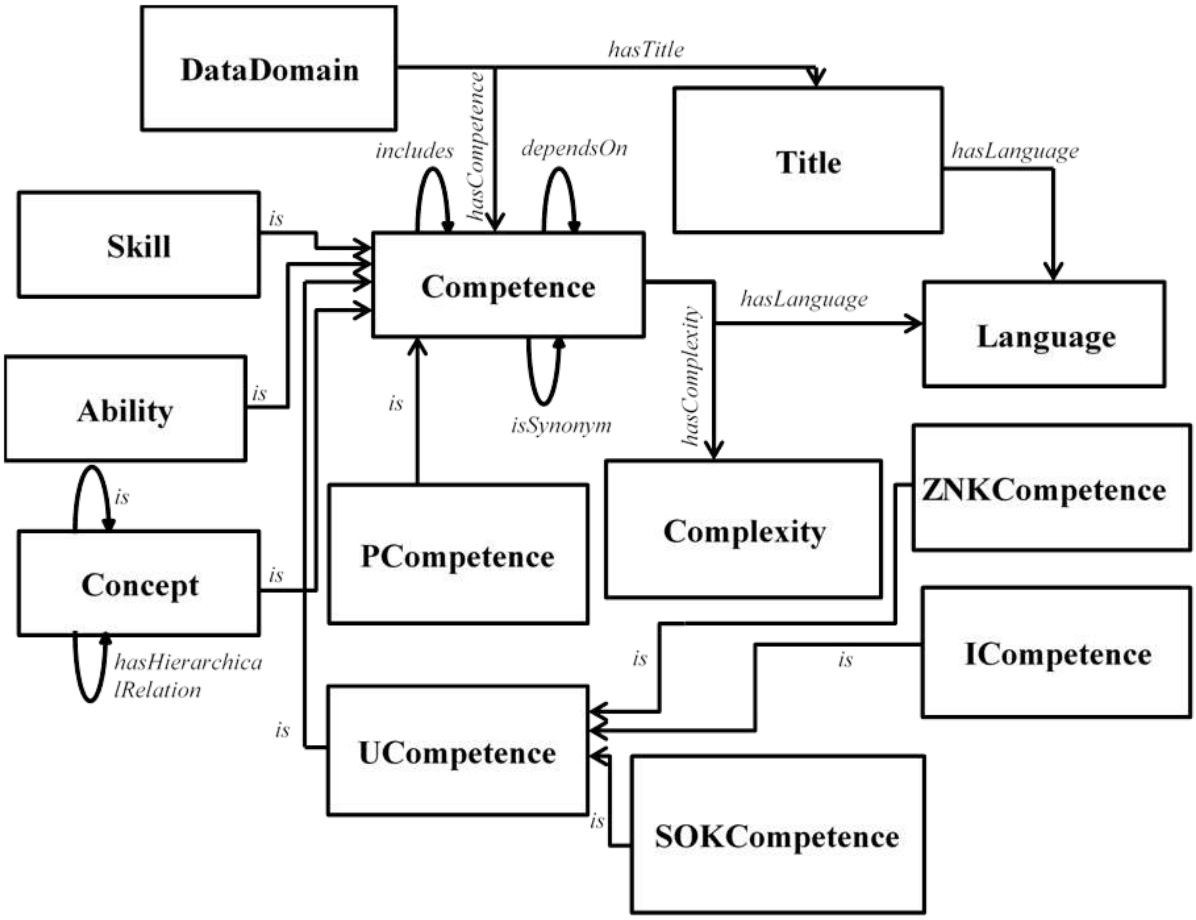

Figure 1: Scheme of ontology of the subject field of discipline.

the basis of the selected cloud-oriented environment WebProtégé, it is most appropriate to use the method of building an ontology proposed by Lytvyn et al. (Lytvyn et al., 2013), which consists of seven steps (Lytvyn et al., 2013, p. 319).

Step 1. Defining the field and scale of the ontology.

Step 2. Ability to use existing ontologies.

Step 3. List of important terms in the ontology.

Step 4. Defining classes and their hierarchy.

Step 5. Defining the properties of classes.

Step 6. Defining the facet properties.

Step 7. Creation of instances.

Therefore, to design a computer ontology of the subject area of the discipline, future specialists in the field of digital technologies in the field of computer technology should be carried out according to the following algorithm:

1. Select on the basis of the scheme proposed in figure 1, competencies of the first level – universal (general, instrumental, social-personal competencies of subject discipline) and professional – on the basis of analysis of the work program of discipline and matrix of competencies. Describe them as instances of the corresponding classes of computer ontology of the study discipline (UCompetence, PCompetence, ZNKCompetence, ICompetence, SOKCompetence). An example of filling the PCompetence class is shown in figure 2.
2. Sequentially allocate competences of the second level by analyzing the list of acquired knowledge, skills and abilities. Describe them as instances of the corresponding classes of computer ontology of the discipline (Concept, Skill, Ability).
3. Based on the analysis of the work program of the discipline and the matrix of competencies, allocate the third level competencies that are implemented within each module of the curriculum and describe them as instances of the corresponding classrooms of the computer ontology (Concept, Skill, Ability).

Table 1: The set of concepts of ontology of the subject discipline.

Ontology concept	Parental concept	Concept description
DataDomain	Thing	Subject field of discipline
Competence	Thing	Competences
Concept	Competence	Concepts (terms) of the subject discipline
UCompetence	Competence	Universal competences of the subject discipline
PCompetence	Competence	Professional competence of the subject field of the discipline
ZNKCompetence	UCompetence	General scientific competence of the subject field of the discipline
ICompetence	UCompetence	Instrumental competences of the subject discipline
SOKCompetence	UCompetence	Sociopersonal / general cultural competences of the subject discipline
Skill	Competence	Skills in the subject field of the discipline
Ability	Competence	Ability of the subject field of the discipline
Language	Thing	Language of presentation of information

Table 2: The set of relations of the ontology of the subject discipline.

Correlation	Definition area	Value range	Description
hasLanguage	Competence	Language	The ratio that sets the language of the presentation of the ontology
hasComplexity	Competence	Complexity	The ratio that sets the level of competence development
includes	Competence	Competence	The relation of inclusion of competences in the competence of a higher level, concepts, skills and abilities – in competence (through the mechanism of imitation)
dependsOn	Competence	Competence	Relationship between the two competencies, concepts, skills or abilities
isSynonym	Competence	Competence	The relation of synonymy to the concepts of the subject field and competencies
is	Concept	Concept	The relationship “is” between the concepts of the subject field
hasHierarchical	Concept	Concept	The ratio of the hierarchy between the concepts

4. Based on the knowledge of the future specialist in the field of digital technologies about the subject area of the discipline and the availability of educational and methodological literature, identify competencies of lower levels and describe them as instances of relevant classes of computer ontology of the discipline (Concept, Skill, Ability). The recommended number of levels of competence in describing the set of knowledge discipline – 3-4. Additional levels can be used in the description of knowledge in the form of concepts of the subject area in the case of availability in the individual modules of discipline a large number of terms of the subject field, which are related hierarchically. For the description of skills and abilities, in most cases it is up to 3-4 levels of competencies.
5. Based on the work program of the discipline and the links proposed in table 2, as well as knowledge of the subject area and the analysis of educational methodical literature, identify the relationship between the competencies described and set them with the following relationships of the ontology of the discipline: includes (the ratio of the inclusion of competencies in a higher level of competence), dependsOn (dependency ratio between two competencies, concepts, skills or abilities). If there is synonymy, set the appropriate relation to isSynonym. In describing the discipline subject field, use the hasTitle and hasLanguage relationship to describe the description of the respective competences in the natural language and language of the description figure 3.

Thus, we will have a computer ontology of the subject area of the academic discipline as shown in figure 4. However, to conduct an analysis to obtain numerical estimates of the feasibility of designing such ontologies of academic disciplines, it is advisable to conduct an experiment and analyze

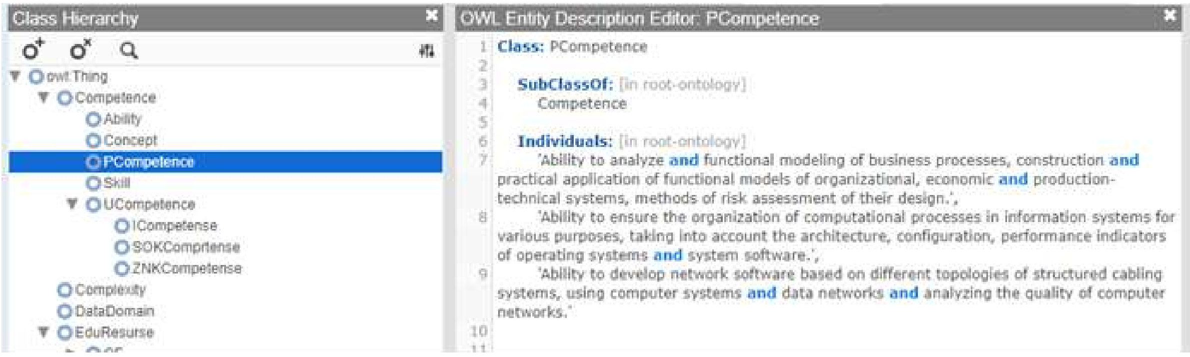

Figure 2: Example of filling the PCompetence class with appropriate instances.

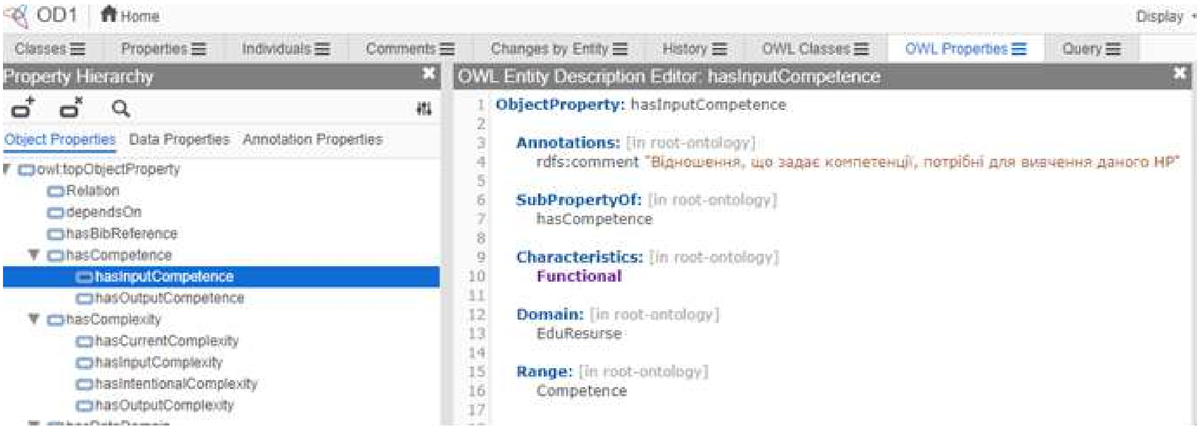

Figure 3: Example of setting the hasInputCompetence relationship between the corresponding instances and classes.

the effectiveness of cloud-based WebProtégé environment and ontologies based on the criteria proposed in (Buyak et al., 2019): 1) speed of construction of sub-ontologies, 2) the number of defects. Another important criterion here is the speed of addition of already created ontologies.

Therefore, an experiment was conducted on the basis of the engineering and pedagogical faculty of Ternopil Volodymyr Hnatiuk National Pedagogical University, which involved 40 students of future specialists in the field of digital technologies (20 students in the experimental group and 20 students in the control group). For the experimental group, the process of designing a computer ontology of the subject area of the discipline was carried out on the basis of the proposed ontological model and methodology based on the use of cloud-oriented WebProtégé environment. The students in the control group carried out the design of a computer ontology of the subject area of the discipline without the use of a model and with the help of declarative programming languages.

The construction of the computer ontology of the subject area of the discipline in both control and experimental groups was modular, i.e. developed as a set of small modules (sub-ontologies), which are then assembled for the formation and use as a single modular ontology. Like ontology learning (ontology extraction, ontology generation, or ontology acquisition), it is the automatic or semi-automatic creation of ontologies, including the extraction of concepts from the corresponding domain and the relationship between these concepts from a natural language text block and their coding with ontological language for easy retrieval. Therefore, each student (both in the experimental and control groups) built 1 ontology of the subject area of the discipline. However, these ontologies can later be combined as sub-ontologies into one computer ontology of educational resources of the university.

In the process of building ontologies of the subject area of the discipline, students use general concepts, which are sufficiently defined in one of the ontologies, and they will be available for other ontologies, which will avoid excessive description of objects of the subject area by reusing certain concepts. It will also make it possible to simplify the semantic rules for finding didactic materials in a particular discipline (Tsidylo and Kozibroda, 2018, p. 259).

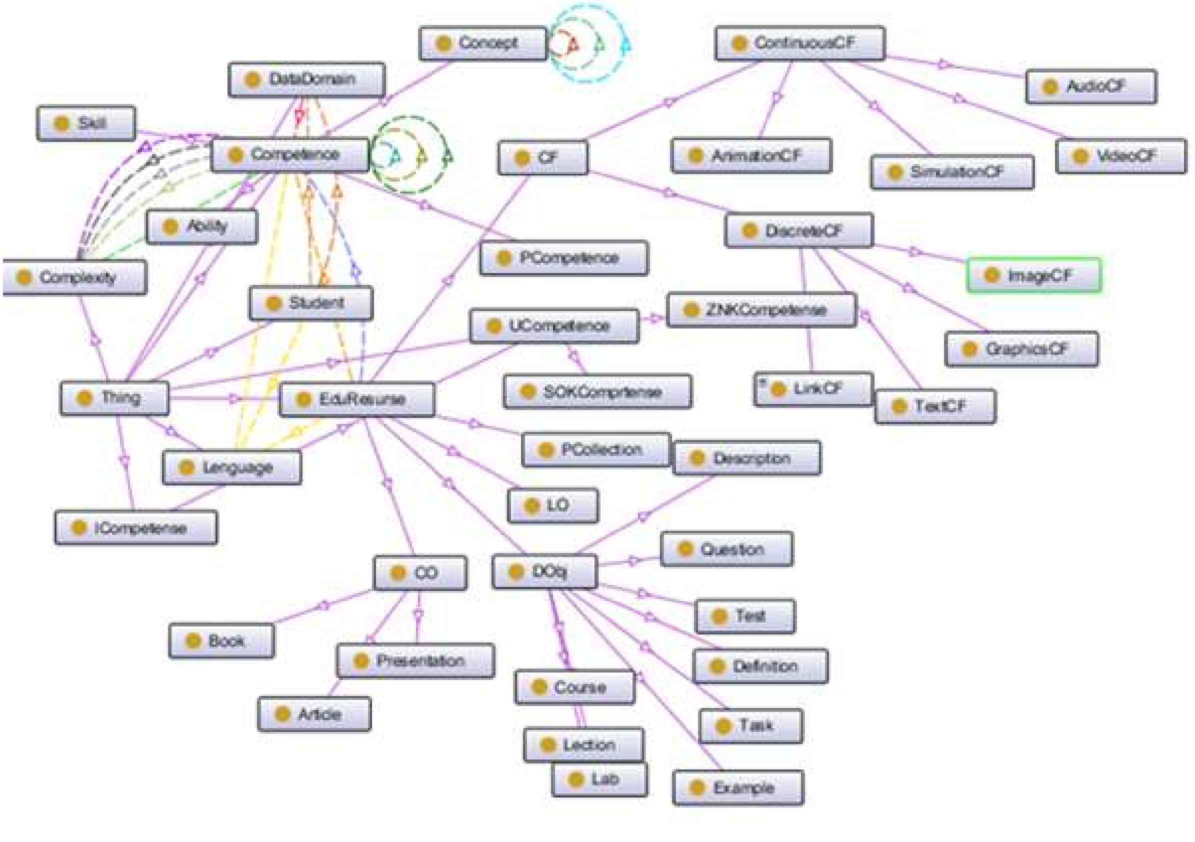

Figure 4: Graphical representation of the computer ontology of the discipline and the relationships between components and classes.

As mentioned above, the process of analysis of the design of computer ontologies of the subject area of the discipline by students of the experimental and control groups was carried out according to the following criteria:

1) *speed of construction of ontologies.* The students of the control group (20 students) and the experimental group (20 students) were allotted with 20 disciplines with appropriate structural elements that should be reflected in the ontology, on the basis of which students should build ontologies of the subject area of the discipline. How long it took the students of the groups to build these 20 ontologies was also taken into account. The results show (figure 5) that the students of the experimental groups coped with this task on average 2.5 times faster;

2) *the number of defects.* The study of this indicator was based on the analysis of 20 constructed ontologies of the subject area of academic disciplines. According to the results of the analysis (figure 6) it was found that future students of the experimental groups, who used the proposed ontological model of the subject area of the discipline and methodology based on the use of cloud-based environment WebProtégé, had significantly fewer defects (almost 2 times) than the students of the control groups, who designed the computer ontology of the subject area of the discipline without the use of the model and with the help of declarative programming languages;

3) *the speed of addition of already created ontologies the number of defects.* This indicator reflects how quickly future specialists in the field of digital technologies will be able to integrate their ontologies of the subject area of the discipline into the supra-ontology of the educational resources of the university. According to the results of the analysis of these indicators (figure 7), the students of the experimental group who used the cloud-oriented WebProtégé environment to integrate their ontologies coped with this task much faster (almost 3 times) than the students of the control groups who did the integration using declarative languages.

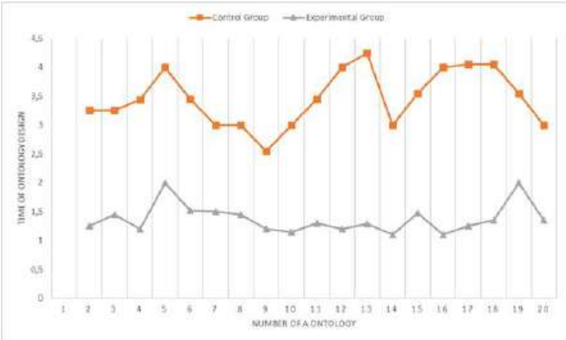

Figure 5: Comparison of the speed of construction of ontologies by the students of the control and experimental groups.

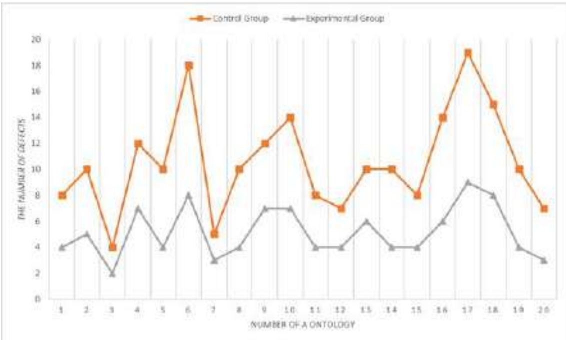

Figure 6: Comparison of the number of defects in ontologies built by the students of the control and experimental groups.

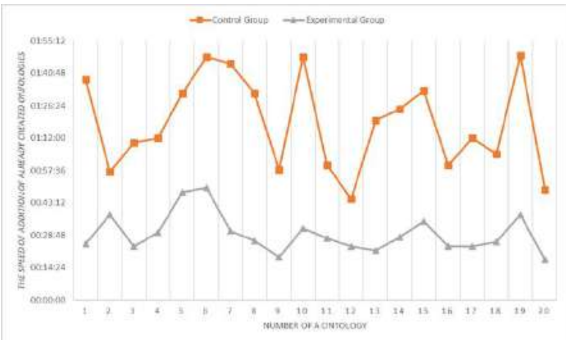

Figure 7: Comparison of the speed of completion of computer ontology by the students of the control and experimental groups.

Thus, in the context of the ontological approach, for the construction of computer ontologies the scheme of ontology of the subject area of the discipline and the use of cloud-oriented environment WebProtégé improves the quality characteristics of designed ontologies such as speed of ontologies, number of defects and speed of addition of already created ontologies.

3 CONCLUSIONS

1. The scheme of ontology of the subject area of the discipline is presented, on the basis of which future specialists in the field of digital technologies will be able to describe many concepts of the future computer ontology of the subject area of the discipline. In addition, a set of relations between them and the corresponding domains of definition and domains of values of relations is presented, in which there can be both the specified concepts, and their child concepts within the ontology. Based on the set of these concepts and the relationship between them using the cloud-oriented WebProtégé environment, future experts in the field of digital technology will be able to conduct ontological design of the subject area of the discipline they need.
2. The main criteria for choosing a CSO are: 1) software architecture and tools development contain information on the required platforms for using the tool; 2) functional compatibility contains information on tools and interaction with other languages and tools for the development of ontologies, translation from some languages ontologies; 3) intuitive interface – covers work with graphic editors, collaborative work of several users and the need to provide multiple uses of ontology libraries.
3. In the process of selecting a method of designing computer ontologies by means of computer ontology systems, the best option in the educational process of the future specialist in the field of digital technologies is the method proposed by Lytvyn et al. (Lytvyn et al., 2013), which provides a number of stages of designing a computer ontologies.
4. The methodology of designing the computer ontology of the subject area of the discipline by future specialists in the field of digital technologies is proposed. Which includes the scheme of the ontology of the subject area of the discipline, selection of a computer ontology systems(a web-based environment WebProtégé) with the help of which the design, the method of computer ontology design and the algorithm for designing a computer ontology of the subject area of the discipline by future specialists in the field of digital technologies will be carried out.
5. The effectiveness of the projected ontologies of the subject area of the discipline in the context of training future professionals in the field of digital technologies has been experimentally tested on such indicators as: 1) the speed of construction

of ontologies; 2) the number of defects; 3) the speed of addition of already created ontologies. Based on the analysis of the results, it should be noted that by all criteria the indicators of students of the experimental group, where the process of designing computer ontology of the subject area of the discipline is carried out on the basis of the proposed scheme of ontology and methodology based on the use of computer ontology system (in our case, web-oriented environment WebProtégé) were higher than the indicators of the students of the control groups who carried out design using declarative programming languages.

6. The continuation of scientific research on the given problem is useful in the study of the dependence of constructed hierarchy concepts in the computer ontology of the subject discipline and the development of ontologically managed information systems on their basis.

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Systematicity of Students' Independent Work in Cloud Learning Environment of the Course "Educational Electronic Resources for Primary School" for the Future Teachers of Primary Schools

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Abstract: The paper deals with the problem of out-of-class students' independent work in information and communication learning environment based on cloud technologies. Results of appropriate survey among students of pedagogical university are discussed and used for preparing courseware "Educational Electronic Resources for Primary School" for the future teachers of primary schools. It is determined that the leading problems are needs in more careful instruction according to features of the task completing, insufficient experience in self-management, the lack of internal motivation. Most of all, students recommend to provide the tasks with detail instruction (oral or written) and to pay attention to careful planning the time that is necessary for full completion of the task. Results of students' learning activity and achievements during study this course in conditions of COVID-19 pandemic are discussed. Some requirements for management of students' out-of-classroom independent work in cloud learning environment are formulated as a result of this analysis.

1 INTRODUCTION

Cloud Technologies is a basis of modern learning. It provides the students with possibility of study that is free in space and time. Students of full time learning also use the cloud pedagogical information and communication environment for out-of-classes independent work that become essentially actual in conditions of COVID-19 pandemic. But learning activities in cloud environment essential differs from traditional work in classroom or homework with short-term tasks. It also differs from learning work on large study projects. New kind of learning activity requires new pedagogical studies in the field of didactic and psychological peculiarities of students' independent work.

Problems of educational activity in cloud environment were analysed in various studies. Liudmyla I. Bilousova (Bilousova et al., 2014) and her scientific school (which part we consider ourself) paid special attention to problems of management of the students' independent work in the information and communication pedagogical environment. Students' educational research with computational simulations has been developed as a method for improving students' self management through creative learning activity (Bilousova et al., 2019b). There was underlined in work of Bilousova et al. (Bilousova et al., 2013) that effective management of student's independent work should be based on comprehensive computer oriented system of pedagogical diagnostics. Semerikov et al. (Semerikov et al., 2018, 2019) have suggested to use computer simulation of neural networks using spreadsheets that give us possibility to introduce this modern technology in educational process of wide kinds of educational programs that are not directly connected

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with computer science. This field of research is very interesting for our present study, because it promotes development of educational research as a method of leaning. The elements of technique of using CoCalc at studying topic "Neural network and pattern recognition" of the special course "Foundations of Mathematic Informatics" are shown in Markova et al. (Markova et al., 2014). The method of computational simulation and modelling is supported by works of Modlo et al. (Modlo and Semerikov, 2018; Modlo et al., 2019), where new tools for modelling of electromechanical technical objects in cloud-based learning environment are suggested. Khazina et al. (Khazina et al., 2016) also consider computer modelling as a scientific means of training. So we can conclude that computational modelling and simulation is popular and actual learning method, which is actively used in cloud learning environment in particular for management students' independent work. This approach improve the level of learning activity to creative and promote students to self-management of their independent work.

Developing the university learning management system for blended study is one of the key issue of fundamental theoretical and practical studies in Kherson State University (Spivakovsky et al., 2013; Kravtsov and Gnedkova, 2018). Implementation of cloud service models into pedagogical information and communication environment is the subject of studies of Markova et al. (Markova et al., 2019). The works of Nechypurenko et al. (Nechypurenko and Semerikov, 2017; Nechypurenko and Soloviev, 2018) also lays in the field of creating the tools for improving the cloud learning environment and deals with creating a plugin that brings the VLab functionality into Moodle and allows to download and install the VLab files to the site with Moodle training courses. Another direction of developing students' learning environment is augmented reality software design for educational purposes that is caring out in (Nechypurenko et al., 2018, 2020b). Now, we have comprehensive cloud learning environment that can support students' independent work and its management from direct through co-management, subsidiary management up to self-management (Bilousova et al., 2020).

The other side of investigations is devoted to the pedagogical theory of students' independent work management. Oleksandr V. Malykhin (Malykhin, 2009) is an author of one of the recent fundamental research, specifically oriented on the problems of management of students' independent work, he has suggested a model of the system of management of the students' independent learning activity in pedagogical university as well as the corresponded pedagogical technology, which has been tested at foreign language learning. Valerii Yu. Bykov (Bykov, 2009) has developed the theory of modern net technologies of open education has analysed the appropriate models of the open education organizational systems. There have been showed in this work (Bykov, 2009) that we should take into account some styles of students learning activity: "Clarification of the student's learning style, its weaknesses and strengths – a necessary and important step towards finding approaches to structuring the content of learning, choosing effective pedagogical technologies (including individualized, group, interactive learning, distance learning, etc.), appropriate organization of the learning environment and inclusion to its structure of these or those means of training, a choice of pedagogical strategies and as a whole improvement of results of educational activity" (Bykov, 2009). Some directions of building the theory of learning styles are also signed in his work.

The basis of effective management of students' independent learning activities in higher education institutions is the study of the didactic conditions of management of students' independent work both theoretically and by means of a questionnaire (Kotova, 2011; Shcherbiak, 2013; Shymko, 2002). Thus, according to (Shcherbiak, 2013) it is determined that third-year students during independent work had such difficulties as unclear requirements, lack of special literature, the discrepancy tasks with the subject of the course. The results of survey of students on the use of information technologies during independent work (Mitriasova, 2013) are interesting for understanding the technique of students' work. As a result of this survey, students mostly use lecture summaries and electronic resources rather than textbooks or other teaching materials (Mitriasova, 2013) in process of their self-preparation for classes. Survey method was used to determine the problems of self-study of primary school teachers in Luhansk Taras Shevchenko National University (Pochynkova, 2013). By results of (Pochynkova, 2013), students often identify such difficulties, when performing independent work: not enough books (not enough information on the Internet), objectives or requirements are unclear, lack of time, trouble finding information, too large amount of information that makes it difficult to study. Survey (Bilousova et al., 2014), which deals with the problems of management of the students' independent work in the information and communication pedagogical environment, has shown that students widely use Internet resources during independent work, but they do it spontaneously and do not obtain proper effect on the success of learning. So management of independent work should be provided by special means in information and communication environment, aimed at improving the efficiency of the use of Internet resources during independent work of students (Bilousova et al., 2014).

Kolgatina (Kolgatina, 2018) took attention for the level of cognitive students' activity in process of independent work and suggested the appropriate system of tasks for independent work on educational discipline "Method of teaching informatics". This tasks are focused on productive and creative activities of students and anticipate their implementation in the Moodle system. The author underline that the most positive results were achieved by students, who characterized by a high and average level of cognitive activity and a certain experience of independent work in pedagogical information and communication environment (Kolgatina, 2018).

Despite the considerable interest of researchers to pedagogical conditions of students' independent work, the problem of empirical research of relations between factors, which determine the effectiveness of independent learning activities is still not exhausted. In particular, one of the actual problem in management of students' independent work in pedagogical information and communication environment is providing the systematicity of such activity. The lack of direct personal contact between student and teacher as well as the lack of personal connections between students during the task execution and presentation of its results needs innovation approach for motivation and help that traditionally provides learning process.

Objectives of this paper is the analysis of pedagogical conditions of providing the systematic learning activity of students' in pedagogical information and communication environment at studying the course "Educational Electronic Resources for Primary School".

2 THEORETICAL BACKGROUND

On the basis of the analysis of psychological and pedagogical scientific works, it has been established that independent work of students is a multi-faceted concept and involves various aspects of its research: as a teaching method (Bondarevskii, 1960; Buriak, 1986; Kobyliatckii, 1978; Ruvinskii, 1984)); as a type of activity (Bortkevich, 1950; Kasianenko, 1988; Kozakov, 1990; Lavrentieva et al., 2019; Nilson, 1976; Nizamov, 1975; Okhrymovych et al., 2000; Semanov, 1963; Skakun, 2004); as a form of organization of the educational process (Esipov, 1961; Graf et al., 1981; Liaudis, 1989; Molibog, 1975); as a learning tool (Arkhangelskii, 1980; Garunov and Pidkasistyi, 1978; Pidkasistyi, 1974; Tolkunov, 1972). In our study, independent work of the student is considered as educational and cognitive activity which he carries out consciously and actively without direct participation of the teacher for the purpose of the set task decision.

Studying the problem of management of independent work of students involves, first of all, the identification of the essence of management, clarification of its role in the student's educational activities. Bespalko (Bespalko, 2018) believes that the diagnostic setting of teaching goals is an indispensable condition for the development of an effective pedagogical technology and we need to build a consistent model of the pedagogical process based on psychological facts and laws (Bespalko, 2018). He has suggested some useful approaches to forming educational goals and building the indicators. We agree with this approach, which requires educational science to investigate the relationships between indicators that can be measured and learning outcomes that can be objectively diagnosed. At present, there is no sufficiently complete system of such indicators and patterns, so the purpose of our work is to try to assess individual patterns associated with the systematic nature of educational activity. Dmitrenko (Dmitrenko, 2000) also promoted a cybernetic approach in the study of learning process intensification. Some modern concepts of organization and management of students' independent work have been built in the study of Dmytrenko and Yaresko (Dmytrenko and Yaresko, 2009) from the viewpoint of cybernetic approach. Psychological aspects of management of students' educational and cognitive activity have been analysed in (Yakunin, 1986; Itelson, 1972). Psychological foundations of the management of educational activities have been grounded by Mashbits (Mashbits, 1989) from the viewpoint of using computers as educational tools. These theories are now used in wide fields of pedagogical studies. Monakhov (Monakhov, 2017) has suggested a modern prognostic model of development of the teaching theory for IT-education. But these patterns are only phenomenological and can not directly become the base of automated pedagogical diagnostic and prognosis system.

An other side of the problem that is of researchers interest are assessment in students' independent work. Mashanova (Mashanova, 1990) paid attention to pedagogical control as a component of managing students' independent work. Now we believe that not only control, but a system of pedagogical diagnostics should be the base of such management (Bilousova et al., 2013).

There are a lot of scientific works that analyse practical results in students' independent work. Experience of management students' independent work in the higher medical school has been shown by Filippova (Filippova, 2010). Independent work of senior pupils on mathematics in the conditions of differentiated education has described by Omelchenko and Voinalovych (Omelchenko and Voinalovych, 2018).

It was defined on the basis of works being observed above that the essence of managing the student's independent work is to implement the interaction of student and teacher, which is aimed at enhancing the student's activities in the educational process and to achieve the goal of learning. As a result of this interaction, the socio-cognitive experience of the student changes, which acquires the features of independent purposeful activity to gain readiness to solve future professional problems. Depending on the nature of the teacher's influence on the student's independent work, the types of management are distinguished (Kolgatin et al., 2018; Bilousova et al., 2020):

- according the distribution of roles in the management between the subjects of the educational process – direct management, co-management, subsidiary management and self-management (Bilousova et al., 2020);
- by the presence of feedback – with feedback and without feedback;
- by the degree of individualization of influence – directed and dispersed;
- by level of using technical equipment – manual and automated.

From the standpoint of a cybernetic approach, the management is a process that is carried out in the following stages: collecting information and evaluating the situation; setting objectives; decision-making on choosing the appropriate method of solving the problem; realization of the decision; control and evaluation of results; adjustment. Each stage has a specific purpose and task assignments, provides for certain actions of the management entity. A teacher can only provide personal interaction with students to manage their independent work, when students' independent work is in progress in classroom. The management of out-of-classroom learning activity in traditional study is based on preliminary instructing, didactic tools and student's experience in self-management of own learning activity. Such situation leads to the lack of creative and productive activity in students' out-of-class study, because teachers have problems with management of such activity by traditional means. Only using the innovation pedagogical technologies, based on information and communication learning environment and cloud technologies, gives us possibility to realize on-line management of students' independent work at distance.

The development of information and communication technologies, in particular cloud technologies, creates the prerequisites for improving the efficiency of management of students' independent work. A number of scientific works is devoted to the practical didactics of the use of ICT for supporting independent work of students: programme languages for forming knowledge and skills in Informatics were used as first computer-based didactic tools (Ershov, 1981); the dissertation of Reva (Reva, 1994) was one of the first works in the field of using applied software for independent work; some computational models have been designed by Synelnyk and Zavora (Synelnyk and Zavora, 2010) for organization of students' independent work; MathCAD environment was used in the course of computational mathematics (Bilousova, 2011; Bilousova et al., 2019b); Excel was adopted for computer modeling (Teplytskyi, 2009); "Expert" software for pedagogical diagnostics was developed (Bilousova et al., 2013); learning search algorithms with tools of cognitive visualization is one of the modern approach (Bilousova et al., 2019a); educational software "GRAN" became a component of the system of information modelling in the training of future teachers of mathematics and informatics (Zhaldak and Khomik, 1998; Zhaldak and Franchuk, 2021; Zhaldak et al., 2021; Horoshko, 2013); complex introducing of ICT into mathematical education was developed by Rakov (Rakov, 2005) and others. In these studies, attention was paid to the disclosure of new forms of educational and cognitive activity of students with the use of information and communication technologies. The analysis makes it possible to put forward a hypothesis about expediency of computer-oriented management of independent work of students in the process of teaching disciplines of the natural-mathematical cycle.

3 EMPIRICAL RESEARCH OF STUDENTS' VIEWPOINTS

To determine the leading problems, which impede students' independent work, we suggested them some questionnaire with a multiple choice. The target group are students of pedagogical university – future teachers. The size of the sample is 53.

The question 1 suggests to the students some hypothetical "opinions" that characterize probable problems, connected with quality and fullness of preliminary instructing, motivation and cognitive interest, students' experience in self-management of independent work: "Sometimes it is difficult to complete a training task at the appointed time, the reason for this is often the following circumstances:" with such variants of an answer:

variant 1 – here is no enough understanding of how to complete a task;

variant 2 – there are other more important things;

variant 3 – there was a mistake in planning time, the task have been left for the last day and time was not enough;

variant 4 – bad health, illness;

variant 5 – the task is not of interest, it is difficult to force itself to borrow it, even if necessary;

variant 6 – fulfilling the task does not affect the achievement of my life goals (does not give the experience that will be needed in life);

variant 7 – the task does not affect my grades at the university (the grading system does not take into account the results of this task);

variant 8 – the task is so complicated (labor-intensive) that it is not possible to execute it.

The answers show (figure 1) that the leading problems are needs in more careful instruction according to features of the task completing, insufficient experience in self-management, the lack of internal motivation. Statistical analysis shows that influence of variants 2, 6, 7, 8, on the systematicity of independent learning activity is significantly less than the above factors (significance level 0.01 according to Pearson's criterion Chi-square). We should also take into account the variant 4, because of importance of health problems for a student as a person.

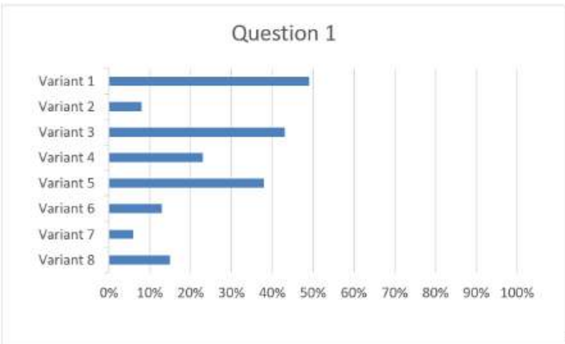

Figure 1: Percentage of students' choice according to Question 1 (Kolgatin et al., 2018).

The same problems were analyzed by students during answering Question 2 from the other viewpoint. The question 2 suggests students to choose some hypothetical "recommendations" for teachers: "To improve the systematicity of students' work, I would recommend teachers:" with such variants of an answer:

variant 1 – not to give for independent work of creative tasks, the order of execution of which is not known in advance;

variant 2 – not to give for the independent work of tasks of a reproductive nature, which is not interesting to perform;

variant 3 – to provide a detailed written instruction to complete the tasks;

variant 4 – to conduct oral consultations and demonstrations in relation to the execution of tasks;

variant 5 – to reduce the grading score for the violation of the term of the tasks;

variant 6 – to provide multiple reminders about the near deadline of the results presentation, using the means of communication;

variant 7 – to calculate the time on the task carefully.

Most of all (figure 2), students recommend to provide the tasks with detail instruction (oral or written) and to pay attention to careful planning the time that is necessary for full completion of the task. Other variants (1, 2, 5, 6) were chosen significantly less (significance level 0.01 according to Pearson's criterion Chi-square).

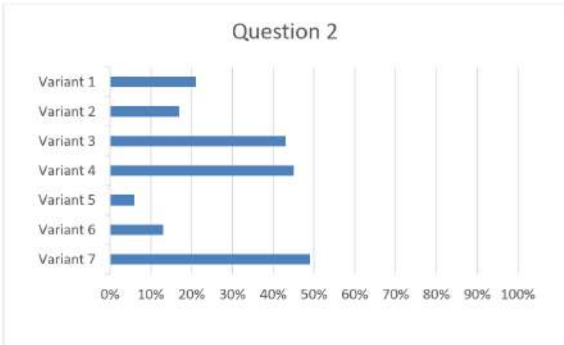

Figure 2: Percentage of students' choice according to Question 2 (Kolgatin et al., 2018).

Such answers to Question 2 confirm the answers to Question 1 (Variants 1 and 4), but are in conflict with variant 5 of Question 1. To increase the cognitive interest of the task we should suggest creative tasks for the students, but such tasks are difficult. If the preliminary instructions are very detailed – we'll lost the creative component in the task. So detail instruction should be provided only in needs in time. This instruction should be individual for the student. One teacher cannot serve all students of academic group in such regime, so we need to organize the collective work of students in information and communication learning environment. We need to use the automated system of pedagogical diagnostics for control every student activity and providing him with context help (Bilousova et al., 2013). There are experimental researches (Surjono, 2015) and theoretical studies (Bykov, 2009) that stress an attention on accordance between student's learning styles and the used method of teaching, "... the way the material presented in online electronics course" (Surjono, 2015). So the automated pedagogical diagnostic system should be comprehensive enough to determine appropriate student's characteristics.

As a result of this discussion let us to formulate some requirements for management of students' out-of-classroom independent work:

- availability of information and communication learning environment which is useful for students;
- students experience in self-management of own learning activity – this experience is provided by systematic independent work, which step by step transforms from direct management by teacher throw co-management with a teacher to self-management according to objectives, plan, system of learning tools and recommendations from teachers and the automated system of pedagogical diagnostics;
- creative elements in the system of learning tasks;
- students' cooperation and communication in process of independent work that increases motivation, helps to follow the time plan and to overcome problems;
- availability of the automated system of the pedagogical diagnostics that provides a student with help in pedagogical design of his learning activity;
- careful design of the system of learning tasks individually for each student with time planning.

4 COURSEWARE STRUCTURE AND BACKGROUND OF EMPIRICAL STUDY

The results of this students' opinions analysis were taken into account at developing courseware "Educational Electronic Resources for Primary School" in learning management system Moodle for future teachers of primary school of the third year study. The purpose of teaching this discipline is for students to master multimedia technologies and gain skills in designing educational electronic resources. The main tasks of studying the discipline are: mastering the theoretical aspects of the use of educational electronic resources; acquaintance with a set of psychological and pedagogical, ergonomic, technical and health requirements for educational electronic resources; mastering the methodological principles of designing author's educational electronic resources; gaining practical experience in developing author's electronic resources to organize the assimilation of educational material by students, to control their academic achievements. Students' competencies in independently finding the necessary resources, its analysing and mastering are in the main focus of this curricular.

The content of the course has been developed according to such topics: stages of information technology history; requirements for educational electronic resources; features of educational electronic resources design; development of educational electronic resources; online support for teachers activity. This course is practical oriented, so interactive and communicative elements are the main part of the courseware: workshops, wiki pages, tests, assignments, databases. The educational process was realised as blended learning, but in conditions of COVID-19 pandemic the weight of online work was essentially grater than it is normal for the blended learning (Polhun et al., 2021). We had a distance educational process factually. So we shell believe that ZOOM sessions realise class work (with high level of independence) and all other students' educational activity is independent work out of class.

Such situation gave us possibility to study systematicity of students' learning activity, because the level of their independence was extremely high. We have used assignments to study the objective situation with systematicity of students' learning activity. These assignments were used for the students to upload reports on completing tasks for out of class work. These tasks contain both creative and reproductive elements, so it satisfy the requirements that are the result of our survey. Creative component assumes solving problems that are new for a student, free searching the resources and possibility to variance the results. Reproductive component was provided by the detailed instruction for methods of solving a problem. Management of students' independent work was realised by this instructions and online or offline teacher's personal consultations. Students' cooperation and communication were organised with a chart and e-mail. Automated system of the pedagogical diagnostics was based on a built-in test system of Moodle and gave teacher possibility of flexible management that assumes on time decreasing the level of management from self-management or subsidiary, or co-management up to direct management using additional consultations (Bilousova et al., 2020). Table 1 contains titles of the considered tasks. The number of students that took part in this work is 14.

5 RESULTS AND DISCUSSION

Our analysis of the empirical results was directed to produce recommendations for better students' independent work management from the viewpoint of systematisity. First of all we observed that there were a group of students, who completed the tasks and uploaded the reports on time as a rule. But some students uploaded their reports essentially later or not completed some tasks at all (figure 3). Therefore, we can conclude that the systematicity of learning activity is an element of student's personal style of learning activity.

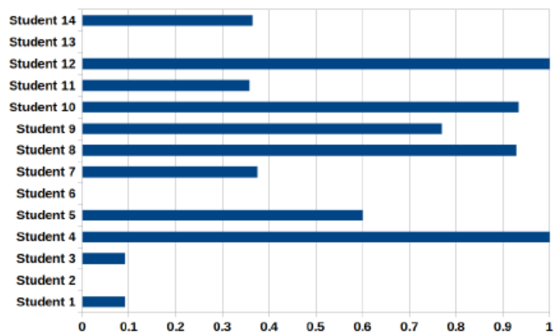

Figure 3: Proportion of tasks that a student completed on time.

Can the late submissions be of better quality because some students spend more time doing it? No, our observations show that the late submissions were not of good quality. Some students downloaded many report files in a short period of time and even at night. To prove this observation we need some statistical analysis. Let grade each student's submission in two scales: 1) the grade of quality (in percent of maximum grade according the curricular) and 2) the grade of systematicity (1 – for on time submissions; 0 – for late submissions). So we have two variable and can evaluate correlation between them. This is point-biserial correlation, so we need to use special correction that increase the value of Pearson's correlation. But this correction is only grounded for normal distribution of the point scale, otherwise we can obtain correlation more than 1. We can not prove this fact because of a small size of a sample. So, we'll use the ordinary Pearson's correlation to demonstrate the effect and some non-parametric significance test to prove statistical significance of this effect, understanding that our evaluation of correlation will be a little smaller and never equal 1. The results of evaluation Pearson's correlation between systematicity and the grade of quality are shown in the table 1. Correlations for some assignments have not been evaluated because the teacher has graded all students' submissions with equal maximum grade point. We need in additional proving significance of this results because of the lack information about the distribution law of our data. So we have prepare 2×2 contingency table with two groups: 1) students, who have uploaded the report on time; 2) students, who have uploaded the report later; and two categories: 1) students, who's report has been graded by maximum grade points; 2) students, who's report has been graded by less than maximum grade points (table 2). Using Pearson's Chi-square test or Fisher's exact test shows that the systematicity and quality of submissions are not statistically independent at high significance level.

The other side of the problem is optimising the task system for the students with different level of their learning activity systematicity. We tried to find some differences in completing our tasks by students with different total systematicity level. Correlations between the the grades of systematicity for a task (as it was describe above) and total number of tasks that have been completed on time by a correspond student have been evaluated for each task and are shown in the table 1. This values are indicators of internal integrity of our task system. We cannot find any essential differences between behaviour of students with high and low level of systematicity according. This result is negative from the viewpoint of developing recommendations for designing special tasks for students with low competence in self management, but it is positive from the viewpoint of the course quality.

6 CONCLUSIONS

1. As a result of survey among students of pedagogical university, the most common problems in systematicity of students' learning activity during the independent work in cloud environment are the lack of instructions, the lack of cognitive interest, students' mistakes in self-management of own learning activity, teachers' mistakes in time planning for the systems of learning tasks.
2. Some requirements for management of students' independent work for fixing these problems are suggested and particularly realised in the

Table 1: Indicators of students' work systematicity on the base of assignments.

Assignment title	**Number of reports that were uploaded on time**	**Full number of uploaded reports**	**Correlation with the grade for quality**	**Correlation with the total number of reports that were uploaded on time**
Characteristics of educational electronic resources	9	13	0.82	0.57
Functions of educational electronic resources	5	14	0.53	0.90
The degree of didactic functions implementation	6	10	0.79	0.67
Characteristics of an educational computer game	5	7	-	0.83
Examples of interactivity	6	11	-	0.66
Crossword	7	12	-	0.88
The simulator in the MapKit environment	6	8	-	0.83
The simulator in the Match environment	6	6	-	-
Interactive presentation	6	12	0.69	0.79
The main didactic function of the educational electronic resource	5	10	0.8	0.88
Examples of educational research tasks	3	10	-	0.68
Characteristics of sites	6	13	-	0.77
Laws and regulations on the creation and use of didactic electronic resources	8	13	-	0.76
Advantages and limitations of offline and online e-resources	7	12	0.52	0.65
Animation	5	8	-	0.89

Table 2: Contingency table for significance test to prove dependence between submissions timeliness and quality.

	Max grade	Less grade
On time submissions	76	0
Late submissions	46	20

course "Educational Electronic Resources for Primary School" for the future teachers of primary schools:

- information and communication learning environment should be available and useful for students;
- students should continuously capture the experience in self-management of own learning activity;
- the system of learning tasks should assume elements for creative students' learning activity;
- students' cooperation and communication in process of independent work should increase motivation, help to follow the time plan and overcome problems;
- the automated system of the pedagogical diagnostics should be worked out to provides a student with help in pedagogical design of his/her learning activity;
- design of the learning tasks system should be individual for each student and assume accurate time planning.

3. It has been shown on the base of our experience that student's trend to complete learning tasks on time or not was stable from one task to another, so this trend was mostly determined by student's style of learning activity and other random factors did less influence.
4. Statistical analysis of the experimental data has shown that systematicity of student's learning activity (as a trend to complete learning task on time) correlates with better quality of this activity results. So it is expedient to motivate students to systematic learning activity, to form correspondent competences of self-management in independent work and to help them with time planning.

7 PROSPECT FOR FUTURE RESEARCH

When distance learning started to be introduced as an element of the educational system, enthusiasts took part in such learning activity mostly. Students had enough competences in self-management and high motivation. Now, online information and communication technologies become the key part of mass education of ordinary students, who are not ready to self-management. So we need in new pedagogical technology, oriented for educational process with essential part of students' independent work that is managed distantly with use of information and communication technologies.

Students' ability to study regular without direct time planning become very important for the success of educational process. And we need to find and systematise pedagogical methods for forming appropriate style of learning activity and competences. We also need to analyse and systematise the features of educational tasks that promote student to systematic and regular work. We should investigate the boundaries of expedient systematicity as the final stage of this work.

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Data Science in Economics Education: Examples and Opportunities

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Abstract: Data science is the field of study that involves tools, algorithms, and knowledge of maths and statistics to discover knowledge from the raw data. Data science is developing fast and penetrating all spheres of life. More people understand the importance of the science of data and the need for implementation in everyday life. Data science is used in business for business analytics and production, in sales for offerings and, for sales forecasting, in marketing for customizing customers, and recommendations on purchasing, digital marketing, in banking and insurance for risk assessment, fraud detection, scoring, and in medicine for disease forecasting, process automation, and patient health monitoring, in tourism in the field of price analysis, flight safety, opinion mining, etc. This article concerns the issue of data science tools implementation, including the Text Mining and Natural Language Processing algorithms for increasing the value of Economics Education for the development of modern and technologically flexible society. The article deeply discusses the opportunities of using Text Analytics and Topic modeling for conducting scientific studies and applying them in the educational process. Presented examples demonstrate the nature of tasks and approaches which could develop students' research skills in the public perception analysis. Such approaches also allow students to gain practical experience in the study and interpretation of the influence of additional metadata, characterizing the comments authors, on differences in their opinions about events, companies, goods, and services. Finally, the Data science study programs for economics at top-20 universities are selected and discovered.

1 INTRODUCTION

2020 was a turning point for the whole world. COVID-19 and the resulting pandemic have identified weaknesses in society and opened up opportunities for development in many areas. The education sector has also felt the significant impact of the pandemic: the digitalization of the educational process, the transition to online learning and the abolition of educational activities – all this forces to seek effective solutions and adapt to new conditions. The field of economics has also undergone significant changes, accompanied by the digitalization of processes, the transition to remote work and changes in service and communication with customers (Soloviev et al., 2020b). The fast-growing world has become even more digital. Therefore, the skill is becoming increasingly popular use data correctly, model processes and make decisions using modern methods and technologies.

Data science is a field of study that includes tools, algorithms, and knowledge of mathematics and statistics to identify knowledge from raw data. Data science is evolving rapidly and is penetrating all walks of life. More people understand the importance of data science and the need to implement it in everyday life. Data science is used in business for business intelligence and manufacturing, for sales offerings and for sales forecasting, marketing for customer customization and procurement recommendations, digital marketing, banking and insurance for risk assessment, fraud detection, valuation and in medicine for forecasting diseases, process automation and monitoring of patients' health, in tourism in the field of price analysis, flight safety, etc. However, the application of data science in education has been relatively limited, and many opportunities for advancing industries have not yet been explored.

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Data science should be used in education to solve scientific problems, for example, in the study of behaviour in economics, in macro- and microeconomics, marketing, finance, agriculture, environmental and ecological economics and so on.

2 LITERATURE REVIEW

Data Science has a big list of tools: Linear Regression, Logistic Regression, Density Estimation, Confidence Interval, Test of Hypotheses, Pattern Recognition, Clustering, Supervised Learning, Time Series, Decision Trees, Monte-Carlo Simulation, Naive Bayes, Principal Component Analysis, Neural Networks, k-means, Recommendation Engine, Collaborative Filtering, Association Rules, Scoring Engine, Segmentation, Predictive Modeling, Graphs, Deep Learning, Game Theory, Arbitrage, Cross-Validation, Model Fitting, etc. Some of these tools were used in the next researches.

Teaching data science, for example, were introduced in (Brunner and Kim, 2016), Big data and Data Science methods presented in (Chen et al., 2012; George et al., 2016; Shoro and Soomro, 2015; Xiong et al., 2017; Cao, 2017; Ignatyuk et al., 2020), machine learning used in (Parish and Duraisamy, 2016; Derbentsev et al., 2020; Guryanova et al., 2020b; Babenko et al., 2021; Nosratabadi et al., 2020; Zelinska, 2020), Monte Carlo method presented in (Balabay and Chernonog, 2007; Patriarca et al., 2017), Artificial Intelligence presented in (Rizun and Shmelova, 2017). Data Science is fast developing. A large volume of information that grows with each passing year makes it possible to build high-precision models that simplify and partially automate the decision-making process. Models are being developed that implement the key data science algorithms for different areas of economics: financial Data Science (Bielinskyi et al., 2021; Brooks et al., 2019; De Prado, 2018; Danylchuk et al., 2019; Soloviev and Belinskiy, 2019; Soloviev et al., 2020a; Guryanova et al., 2020a; Kuzmenko et al., 2020; Klymenko et al., 2019), for institutional economics – (Prüfer and Prüfer, 2018; Hrabovskyi et al., 2020; Ilchuk et al., 2019; Oliskevych et al., 2018; Shi et al., 2020; Matviychuk et al., 2019), for agriculture – (Kaminskyi et al., 2020; Nehrey et al., 2019; Voronenko et al., 2020), for taxation – (Ausloos et al., 2017), and labor market – (Oliskevych and Lukianenko, 2019).

Data Science developing for education discussed in (National Academies of Sciences, Engineering, and Medicine et al., 2018; Volkova et al., 2019; Perevozova et al., 2020; Dimitrov et al., 2019).

3 DATA SCIENCE: PRINCIPLES AND TOOLS

Data Science in education is a multidisciplinary approach to technologies, processes, and systems for extract knowledge, understanding of data, and supports decision-making under uncertainty. Data science deals with mathematics, statistics, statistical modeling, signal processing, computer science & programming, database technologies, data modeling, machine learning, natural language processing, predictive analytics, visualization, etc. Data Science in education has two aspects of the application: (i) the management and processing of data and (ii) analytical methods for analysis and modeling, and includes nine main steps (figure 1). The first aspect includes data systems and their preparation, including databases facilities, data cleansing, engineering, visualization, monitoring, and reporting. The second aspect includes data analytics data mining, machine learning, text analytics, probability theory, optimization, and visualization. The basis of the learning process is the availability of relevant data that is of sufficient quality, appropriately organized for the task. Primary data often requires pre-processing. First of all, it is necessary to investigate the availability of the necessary data and how they can be obtained. The data search ends with the creation of a data set in which data coexistence is to be provided. Data science has a wide range of tools for data evaluation and preparation, in particular for data mining, data manipulation (value conversion, data aggregation and reordering, table aggregation, breakdown or merge of values, etc.) and validation of data (checking format, ranges of test values and search in legal values tables). The problem of missing values is solved by using different analytical methods: simulation, inserting default values, statistical simulation. Data science provides broad opportunities for text analytics. In addition, the use of data science tools facilitates work with big data. The main approaches in Data Science are Supervised learning models and Unsupervised learning models.

3.1 Supervised Learning Models

Supervised learning is one of the methods of machine learning, in which the model learns on the basis of labeled data. Using Supervised learning is possible to decide on two types of tasks: regression and classification. The main difference between them is the type of variance that is predicted by the corresponding al-

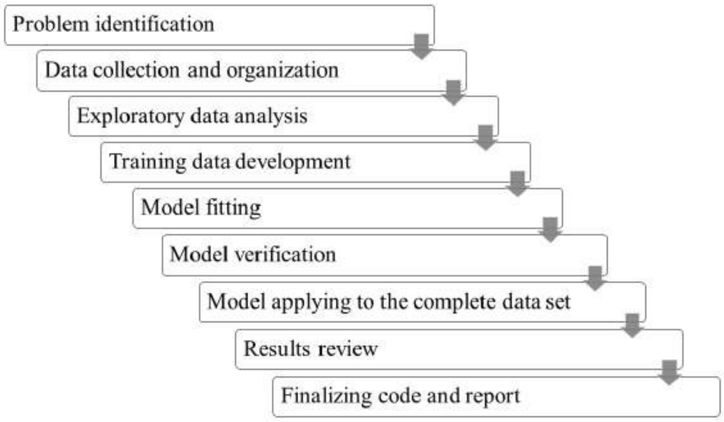

Figure 1: Data Science process.

gorithm. In regression training, it is a continuous variable, in the classification, it is a categorical variable. To solve these problems, many algorithms have been developed. One of the most common is a linear and logistic regression, a decision tree.

Linear regression. Regression analysis can be considered as the basis of statistical research. This approach involves a wide range of algorithms for forecasting a dependent variable using one or more factors (independent variables). The advantage of applying such an approach to modeling is the simplicity and clarity of the results, the speed of learning, and the release of the forecast. The disadvantage is not always sufficiently high precision (since in economics and finances, the linear relationship between changes is rare).

Logistic regression is used when it is necessary to predict the release of a binary variable using a dataset of continuous or categorical variables. Situations, where the parent variable has more than 2 possible values, can be simulated by a one-vs-all approach when constructing a logistic classifier for a possible output, or one-vs-one when constructing logistic classifiers for each possible combination of categories of the original variable. The dependence between the independent and the logarithmic variable in logistic regression is linear, the only difference with linear regression is sigmoidal functions, which converts a linear result in the probability of belonging to a class within [0; 1]. The advantages and disadvantages of logistic regression are due to the advantages and disadvantages of linear regression. This is the speed of the algorithm and the possible interpretation of the results, on the one hand, and a little accuracy – on the other. Logistic regression is often used to construct vote-counting models. An important factor in this is the interpretation of its results. The influence of each factor is clearly expressed by the magnitude of the coefficient b, which allows it to be clearly defined which of them positively and to what extent influence the decision.

A **decision tree** is an approach to both regression and classification. It is widely used in intelligent data analysis. The decision tree consists of “nodes” and “branches”. The tree nodes have attributes that are used to make decisions. In order to make a decision, it is needed to go down to the bottom of the decision tree. The sequence of attributes in a tree, as well as the values that divide the leaves into branches, depends on such parameters as the amount of information or entropy that the attribute adds to the prediction variable. The advantages of decision trees are the simplicity of interpretation, greater accuracy in decision-making simulation compared with regression models, the simplicity of visualization, natural modeling of categorical variables (in regression models it is needed to be coded by artificial variables). However, the decision trees have one significant drawback – low predictive accuracy (James et al., 2013).

3.2 Unsupervised Learning

Unsupervised learning describes a more complex situation in which, for each observation $i = 1, ..., n$, observation of the measurement vector x_i, but without any variables in the output y_i. In such data, the construction of linear or logistic regression models is impossible, since there are no predictive variables. In such a situation, a so-called “blind” analysis is conducted. Such a task belongs to the class of tasks of unsupervised learning, due to the absence of an output variable that guided the analysis. Unsupervised learning algorithms can be divided into algorithms for space reduction and clustering algorithms. The main task of clustering is to find patterns in the data that allow you to divide the data into groups and then in a certain way analyze them and give them an interpretation.

K-means is one of the most popular clustering algorithms, whose main task is to divide n observations into k clusters. The minimum sum of squares is the distance of each observation to the center of the corresponding cluster. This algorithm is iterative, at each step the cluster centers are re-indexed and redistributed observation between them until a stable result is achieved. The benefits of such an algorithm of clustering are the simplicity, speed, and the ability to process large amounts of data. But the user must specify the number of clusters he wants to use for clustering before computing; the instability of the result (it depends on the initial separation of points between the clusters).

Hierarchical clustering is an alternative approach to clustering, which does not require a preliminary determination of the number of clusters. Moreover, the hierarchical clustering ensures the stability of the result and gives the output an attractive visualization based on the tree-like structure of observations/clusters – dendrogram. This clustering algorithm uses different distance metrics and cluster agglomeration cluster criteria, which makes it very flexible to the data on which clustering is performed. However, the disadvantage of hierarchical clustering is the need to calculate the matrices of the distance between observations before agglomeration, which complicates the application of this algorithm for large data and data with many dimensions.

Time series analysis. A time series is built by observations that have been collected with a fixed interval. It could be daily demand, or monthly profit growth rates, number of flights, etc. The time series analysis takes an important part in the analysis of data that covers the region, from the analysis of exchange rates to sales forecasting (Nehrey and Hnot, 2017; Voronenko et al., 2021). One of the tasks of time series analysis is the allocation of trend and seasonal components and the construction of the forecast. There are many algorithms that have been developed, and we consider models such as ARIMA and Prophet.

The **ARIMA** algorithm is one of the most common algorithms for forecasting time series. The basic idea is to use the previous time series values to predict the future. This can use any number of lags, which makes such an approach difficult in setting because it is necessary to select the parameter so as to minimize the error and not override the model. ARIMA is often used for short-term forecasting. A disadvantage is the complexity of learning a model in many seasonal conditions.

Algorithm Prophet was developed by Facebook at the beginning of 2017 for forecasting based on time series (Nehrey and Hnot, 2017). It is based on an additive model in which nonlinear trends are of annual and weekly seasonality. This approach also allows to model holidays and weekends, thereby allowing to predict residuals in a time series. Also, the Prophet is insensitive to missed values, the bias in the trend, and significant residuals, which is an important advantage over ARIMA. Another advantage is the rather high speed of training, as well as the ability to use large-scale time series.

4 TOPIC MODELING IN DATA SCIENCE

Under the notion of texts mining in natural language we understand the application of methods of texts computer analysis and presentation in order to achieve the quality, which corresponds to the "manual" processing for further usage in various tasks and applications. One of the actual tasks of automatic texts mining is topic modelling.

4.1 Latent Dirichlet Allocation

Topic modelling is a statistical approach to extract the hidden semantics that occurs in a collection of documents or reviews. *Latent Dirichlet Allocation (LDA)* model proposed by (Blei et al., 2003) is one of the most notable approach for unsupervised topic modeling, which assumes documents and the words within them are derived from a "generative probabilistic model". Within the class of unsupervised statistical topic models, themes are defined as distributions over a vocabulary of words that represent semantically interpretable "topic" (Roberts et al., 2014). 'Meaning' of those topics (usually, in the form of topic Label and topic Description) is an emergent quality of the relationship between words (Robinson, 2019; DiMaggio et al., 2013). The task of topic meaning recognizing is often fraught with difficulty and requires the application of a triangular approach to its implementation, namely: (i) a literature review of existing topics found in the analyzed problem domain; (ii) independent work of experts on assigning labels to topics; (iii) conducting joint expert discussions in order to compare and revise the obtained labelling results.

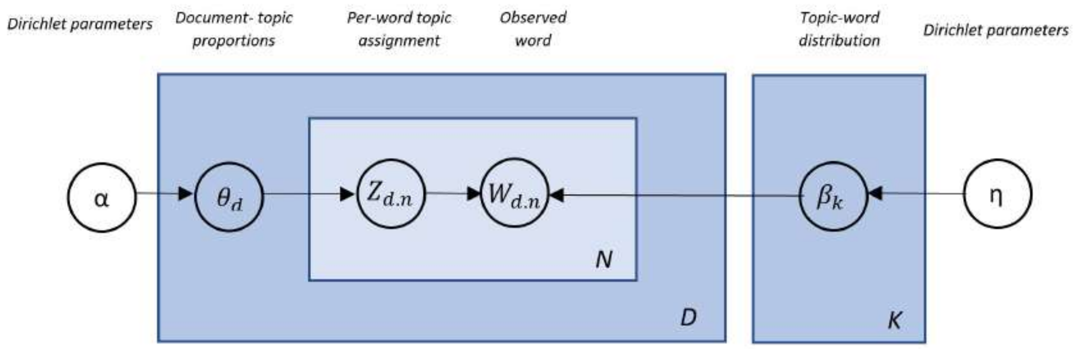

Figure 2: Latent Dirichlet allocation model (Blei, 2012).

As for main assumption of LDA method, there are the following (Roberts et al., 2016): (i) document is represented as a mixture of topics; (ii) each topic are present in many documents; (iii) each word within a given document belonging to exactly one topic; (iv) each document can be represented as a vector of proportions that denote what fraction of the words belong to each topic.

The basic LDA model is shown in figure 2.

Figure 2 serves as a visual explanation of the model and could be described as follows: (i) we have D documents and K topics; (ii) each topic presented by β_k words distribution over the vocabulary within the topic k; (iii) each document is presented by θ_d topic proportions within the document, where $\theta_{d,k}$ is the topic proportion for topic k in document d. Finally, we have (iv) for each n^{th} word in the document d – topic assignments $z_{d,n}$ (depends on the per-document topic proportions θ_d) and (v) for each d^{th} document – observed words $w_{d,n}$ which is an element from the fixed vocabulary (depends on the topic assignment $z_{d,n}$ and all of the topics $\beta_{1:k}$) (Blei, 2012).

In is obviously that data scientist in cooperation with other science domains increasingly seek ways to apply NLP and especially LDA topic modelling techniques to extract, organize, recognize, label and classify customers opinions and experiences (Kobayashi et al., 2018a). Next examples demonstrate the possibilities to sol the apply LDA topic modelling for solving: (i) human resources management, (ii) service quality assessment, (iii) research & development policy coordination tasks and (iv) strategic planning in universities.

Kobayashi et al. (Kobayashi et al., 2018b) used topic modelling to summarize the worker attributes and find worker attribute constructs and use these to cluster jobs. 140 main topics were identified, and such skills, as, for example, interpersonal communication (vocabulary of words: communication, written, oral, verbal, interpersonal, presentation, effective, listening); analytical and problem-solving (vocabulary of words: problem, solving, analytical, solver, troubleshooting, approach, abilities, capabilities); data analytical skills (vocabulary of words: data, Analysis, quantitative, research, statistics, economics, statistical, modeling); willingness to travel and the ability to operate on a flexible work schedule (vocabulary of words: travel, willingness, willing, work, time, needed, internationally, international) and other. As authors mentioned, topic modelling showed that it is not only possible to classify job information from vacancies but that we can also derive behavioral characteristics that are valued or required by employers from potential or existing job holders. Moreover, as a further analysis of this research was planned the analysing trends of worker attributes required by organizations (i) over time, (ii) occupations, companies, and (iii) geographical regions, and also (iv) possibility to build a network of work activities to examine relationship among tasks.

Wallace et al. (Wallace et al., 2014), Sharma et al. (Sharma et al., 2016) captured the main positive and negative words within latent aspects (topics), which characterise interpersonal manner, technical competence, and systems issues (López et al., 2012) from online physician reviews. Similar with previous work, James et al. (James et al., 2017) based on López et al. (López et al., 2012) categorization, examined unstructured textual feedback of physicians in order to determine: (i) how the extracted sentiment and topics compared to traditional identified dimensions of service quality in healthcare and (ii) what tone and topic elements were driving patients' service quality ratings. As a main finding were the following list of topics and their tone: (1) Negative system quality: Staff and Timeliness (vocabulary of words: office, staff, time, doctor, wait, appointment); (2) Positive interpersonal quality: Physician Compassion (vocabulary of words: doctor, caring, great, knowledgeable, excellent, recommend); (3) Negative system quality: Experience (vocabulary of words: told, don't, doctor, ask, bad, money, call); (4) Positive Technical quality: Family (vocabulary of words: doctor, questions, staff, practice, children, son, pregnancy); (5) Positive Technical quality: Surgery (vocabulary of words: surgery, pain, procedure, staff, hospital, knee, cancer, age); (6) Negative Technical quality: Diagnosis (vocabulary of words: years, treatment, medical, patient, conditions, test, diagnosis, time, treated). The obtained results allowed the authors to establish the dependence on the degree of influence of the identified aspects (topics) on the general perception of the physician's quality, as well as the behavioural characteristics of patients when choosing a doctor online, depending on the content of comments and overall rating.

4.2 Structural Topic Modelling

When conducting research on the basis of textual documents or customers comments, researchers often have a more of information "about the text" than "about the content of the text". From the perspective of topic modelling as a statistical approach, the existence of such information "about the text" (metadata) allows and initiates the inclusion in the model of additional covariates that could influence the following components of the topic model: (1) Proportion of the document devoted to the topic ("prevalence of the topic"). For example, we can know that "clients who buy products online are more likely to talk about delivery problems than clients who buy offline". (2) Word rates used in the discussing of the topic ("topical content"). For example, we can clarify that "when clients talking about delivery problems, clients who buy products online are more likely discuss the problems about products returning, but patients clients who buy offline are more likely discuss staff rudeness issues" (Roberts et al., 2019). Such possibilities are proposed by *Structural topic modelling (STM)* as an extension of the LDA framework (Robinson, 2019; Roberts et al., 2019, 2013) .

Drawing analogies with LDA: (i) each document in STM arises as a mixture over K topics; (ii) topic proportions (θ_d) can be correlated (LDA limitation 1); (iii) topics prevalence θ_d can be influenced by set of covariates X through a standard regression model with covariates; (ii) for each w_n word in the document d (iii) a topic $Z_{d,n}$ is drawn from the document-specific distribution, and (iv) conditional on that topic, a word is chosen from a multinomial distribution over words parameterized by $\beta_{d,k,v}$, where $k = Z_{d,n}$. This distribution can include a second set of covariates Y (Roberts et al., 2019). Thus, the main differences between the LSA and STM models (figure 3) are that the prevalence (content) parameters determined in the LDA by the general a priori Dirichlet parameters $\alpha(\eta)$ in the STM model are replaced with prior structures specified in the form of generalized linear models parameterized by document specific covariates $X(Y)$ (Hu et al., 2019) These covariates inform either the topic prevalence (covariates X) or the topical content (covariates Y) latent variables with information "about the text" (metadata).

5 EXAMPLE OF STRUCTURAL MODELLING ALGORITHMS APPLICATION IN EDUCATION

In order to study customer perception of the quality of services, assess their satisfaction with goods or services received, as well as identify factors that influence customer acceptance of new offers on the market, students were asked to use STM tools. As a data source 610 textual comments about hospitals from the site http://www.ratemyhospital.ie/ (over the past two years – 2018–2019) were used. STM package allows to use all additional variables to demonstrate the power of meta-data for topic modelling. With this aim, textual comments data was extended by information about (1) hospital ownership (private, public), (2) sentiment (positive or negative) (table 1) (Ojo and Rizun, 2020). After that, all steps of text pre-processing were performed.

First, the STM model's setup were performed. To determine the optimal number of topics, STM models from 10 till 30 topics were built were analyzed. Semantic coherence is maximized when the most probable words in a given topic frequently co-occur together, and it is a metric that correlates well with a human judgment of topic quality. Having high semantic coherence is relatively easy, though, if we only have a few topics dominated by very common words, so we wanted to look at both semantic coherence and exclusivity of words to topics. So, the most valuable number of topics should be very coherent and also very exclusive. Looking at figure 4, we draw the conclusion that the 15 topics suit the most to these criteria. Most of the topics, in this case, are above the average of exclusivity and have high coherence, especially compared to the other number of topics which are often spread out on both axes. 15-topic STM model was selected based on subjectively optimal combination of the average semantic coherence and exclusivity outcomes.

As a result, for 15-topic model, we received the (i) topic-words distribution β; (ii) document-topic pro-

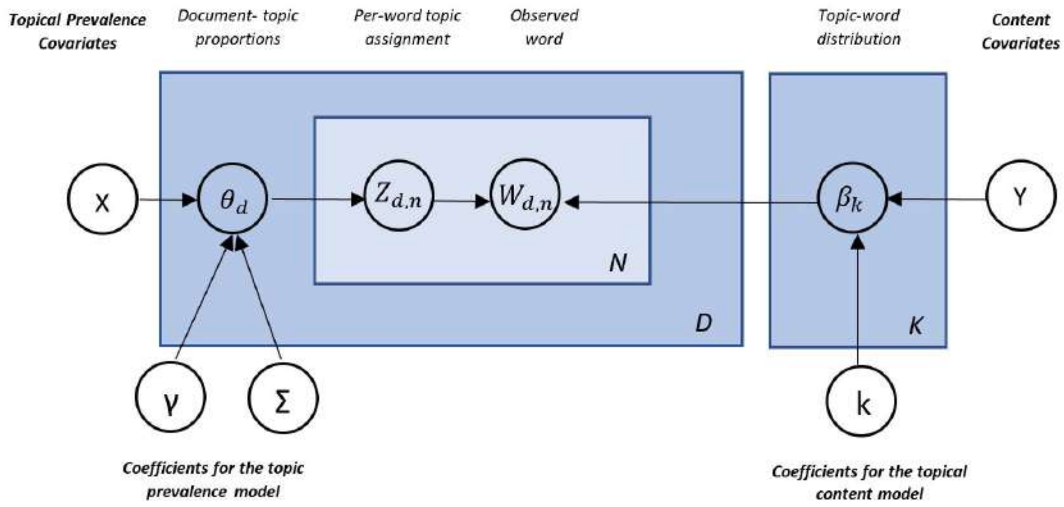

Figure 3: A graphical illustration of the structural topic model (Roberts et al., 2016).

Table 1: Comments before pre-processing.

Comments	Hospital Ownership	Sentiment
A lovely friendly patient-focussed hospital	Public	Positive
Consultant I found seriously lacking compassion for my mother the patient. Sniggered while informing us that while my mother's condition is uncomfortable, it is not life threatening. To be frank, consultant spoke down to us.	Public	Negative
Tullamore is a very clean hospital and looks very well. All staff I had the pleasure of meeting were lovely and very professional at all times. The staff in all capacities do not receive enough thanks for the jobs they do	Private	Positive

portions θ; (iii) list of Highest probability-, FREX-, Lift- and Score-keywords (*Highest Prob*: are the words within each topic with the highest probability; *FREX*: are the words that are both frequent and exclusive, identifying words that distinguish topics; *Lift*: give more weight to words that appear less frequently in other topics by dividing their frequency into other topics; *Score*: score words are weighted by dividing the log frequency of the word in the topic by the log frequency in other topics (Roberts et al., 2013; Chang, 2015; Griffiths and Steyvers, 2004)); (iv) set of documents, mostly associated with this topic. The figure 5 allows us to get information on the share of the different topics at the overall corpus.

Second, students needed to realize the *Topics labelling* step. For that: (1) two students independently labelled the topics to produce the first version of labels based on top weighted keywords; (2) two students discussed the labels and resolved discrepancies in labelling; (3) two students independently refined topic labels based on the computationally guided deep reading 20 of the most representative tweets of the topics; (5) two students agreed on final 15 topic labels and jointly developed the topics descriptions (short summarization of the topic content) (Ojo and Rizun, 2020). The result of topic labelling is presented in the table 2.

Third, the STM covariate analysis could be performed. In this stage, we aimed the evaluating the *Sentiment* effect on the formation of more positively and more negatively oriented aspects of hospitals service quality (HSQ). Thus, we use Sentiment metadata as Covariate in the STM model. Formally, we can identify an aspect as negative if, according to the results of effect estimation, the proportion of this aspect in negative comments (Sentiment = Negative) is significantly higher than in comments in positive comments (Sentiment = Positive). According to the results of our experiment, 5 topics (33.33%) are positive (right side of figure 6), and 10 topics (66.66%) are negative (left side of figure 6).

The dots in the figure 6 indicated the mean values of the estimated proportion differences (power of influence, PI) with 95% confidence intervals, allows us

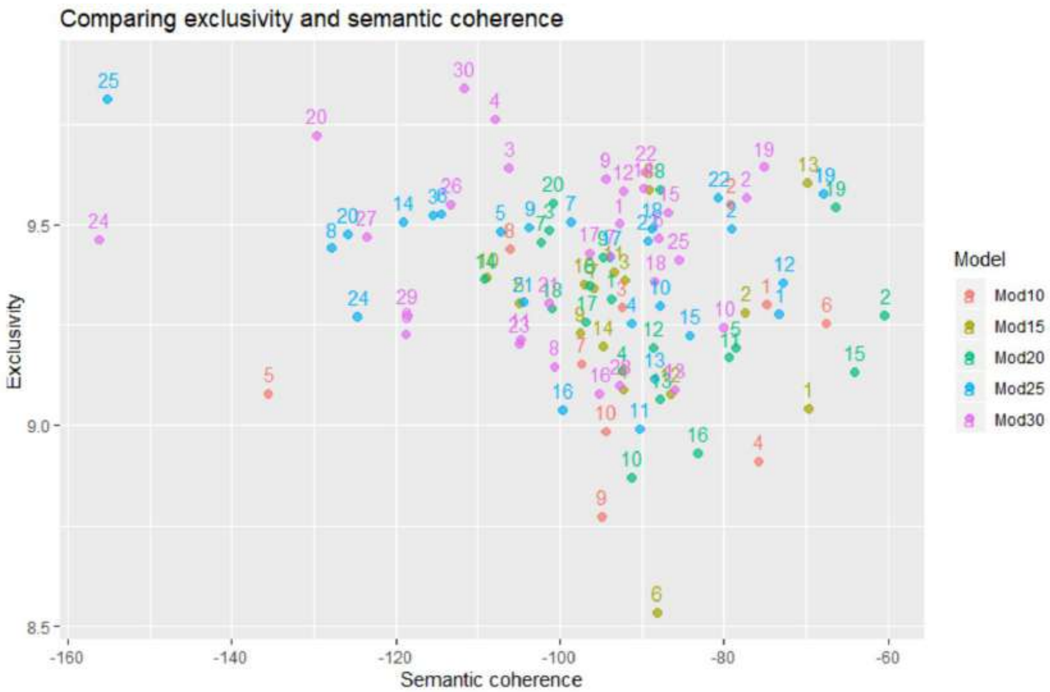

Figure 4: Semantic coherence and exclusivity of STM models.

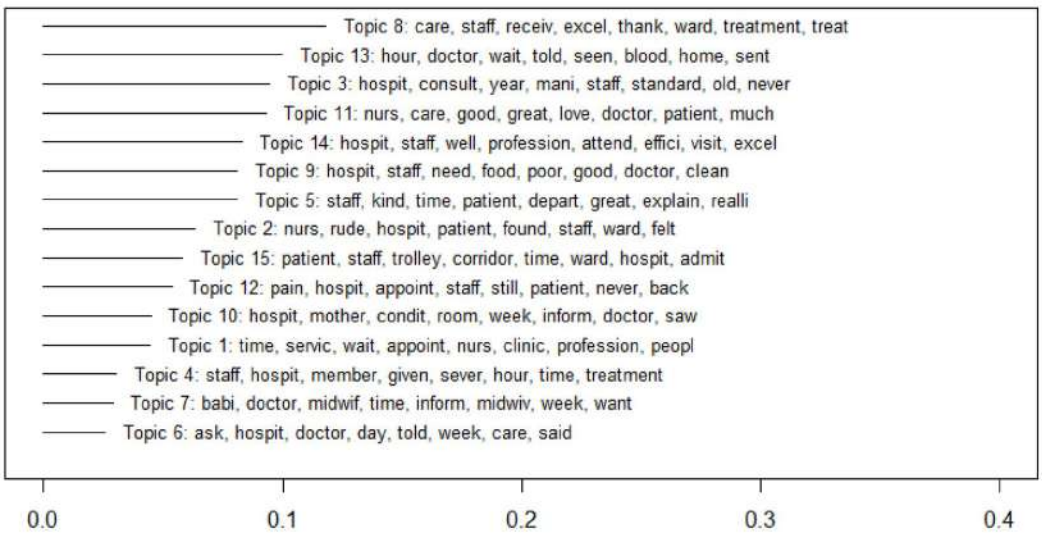

Figure 5: Expected topic proportions over corpus.

to evaluate the relative degree of influence of sentiment on of hospitals service quality aspects. For example, the five most negative Topic of are (1) *Information Exchange with Patient/Family* (Topic 13) with highest power of negative influence; (2) *Communication Skills* (Topic 2); (3) *A&E/Admission* (Topic 12), (4) *Waiting Time* (Topic 4) and (5) *Patient-Focusing Service* (Topic 6). In turn two most positive topics are (1) *Service Rapidness* (Topic 14); (2) *Personnel Reliability/Treatment* (Topic 8). Knowledge about Topics with a positive and negative impact of comments Sentiment allow to indicate the strength of patient satisfaction/dissatisfaction with the hospitals service quality.

Fourth, the power of *Time* influence on positive and negative Topics dynamics (from 2018 to 2019) using the STM model (with Year and Sentiment as a Covariates) should be performed. In terms of the

Table 2: Topics labels.

No	Topics label	Topic keywords	Topic proportion, %
1	Appointment Time Reliability	time, service, wait, appoint, nurses, clinic, profession	4.47
2	Communication Skills	nurses, rude, hospital, patient, found, staff, ward	6.34
3	Service Standards	hospital, consult, year, many, staff, standard, old	9.45
4	Waiting Time	staff, hospital, member, given, sever, hour, time	3.03
5	Staff Feedback/Explanation	staff, kind, time, patient, depart, great, explain	8.09
6	Patient-Focusing Service	ask, hospital, doctor, day, told, week, care	2.56
7	Maternity Unit/Care	baby, doctor, midwife, time, inform, midwife, week	2.89
8	Personnel Reliability / Treatment	scare, staff, receive, excel, thank, ward, treatment	11.81
9	Food Service	hospital, staff, need, food, poor, good, doctor	8.10
10	Hospital Environment	hospital, mother, conditions, room, week, inform, doctor	4.48
11	Care and Recovery	nursed, care, good, great, love, doctor, patient	9.29
12	A&E/Admission	pain, hospital, appoint, staff, still, patient, never	5.37
13	Information Exchange with Patient/Family	hour, doctor, wait, told, seen, blood, home	9.99
14	Service Rapidness	hospital, staff, well, profession, attend, efficiency, visit	8.31
15	Ward/Hospital's Facilities	patient, staff, trolley, corridor, time, ward, hospital	5.82

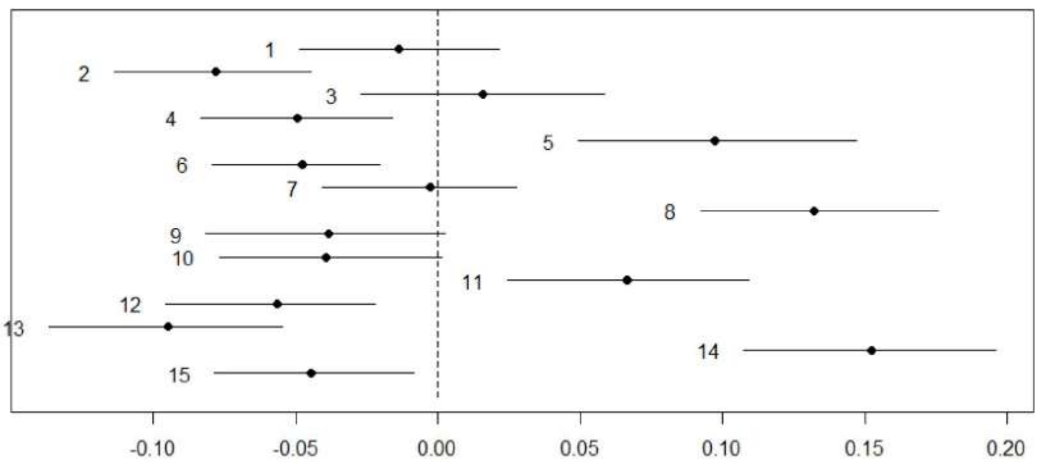

Figure 6: Difference in the power of Sentiment influence on topic proportion.

Influence of the Time Factor on the Service Quality, the following four groups of HSQ Topics can be distinguished: (1) Topics causing the growth of patient satisfaction with the Service Quality over the time: positive topics with a positive dynamic over the time; (2) Topics causing a recession in patient satisfaction with the hospitals service quality (HSQ) over the time: positive topics with a negative dynamic over the time; (3) Topics causing the growth of patient dissatisfaction with the HSQ over the time: negative topics with a positive dynamic over the time (4) Topics causing a recession in patient dissatisfaction with the HSQ over the time: negative topics with a negative dynamic over the time.

As an indicator that allows us to identify the direction and growth rate (GR) of change in the level of positive or negative comments describing the Topic, the slope of the regression (dependence between the proportion of Positive/Negative Aspects and Time) will be used. The presented four charts (figure 7 a, b, c, d) show examples of four possible types of Influence of the Time Factor on the Service Quality:

1. Positive impact on Service Quality over the time: Service Rapidness topic characterized by growth rate (GR=1.100763) of patient satisfaction with the HSQ over the time (figure 7, b);
2. Worsening of Service Quality over the time: Personnel Reliability/Treatment topic characterized by and recession (GR=0.821713) in patient satisfaction with the HSQ over the time (figure 7, a);
3. Negative impact on Service Quality over the time:

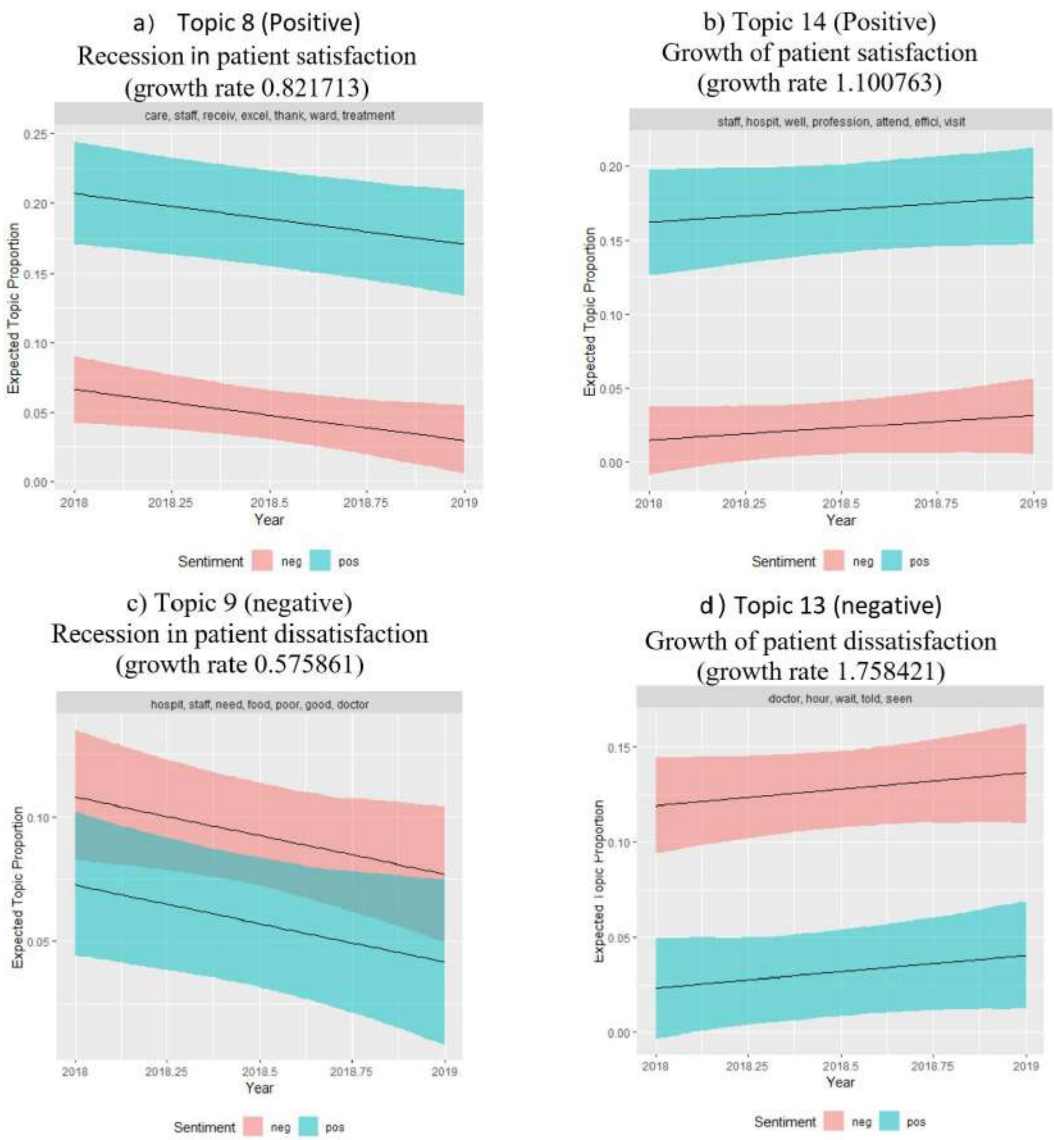

Figure 7: Examples of identification the influence of the Years Metadata.

Information Exchange with Patient/Family topic characterized by growth (GR= 1.758421) of patient dissatisfaction with the HSQ over the time (figure 7, d);

4. Improvement of Service Quality over the time: Food Service topic causing a recession in customer dissatisfaction (GR= 0.575861) with the HSQ over the time (figure 7, c).

As a result, student could see that the largest number of aspects (37.5%) has a negative impact on the HSQ. The highest degree of growth in patient dissatisfaction is characterized by *A$E/Waiting Time* topic. Moreover, this growth rate is not only the largest in the category of Negative impact, but in all analyzed topics. The most rapid (within the whole set of topics) decrease in the number of positive comments is characterized by the aspect of *Maternity Unit/Care*. The group of topics on which improvement in their quality is noted is 25.1%. At the same time, the Hospital Environment is characterized by the highest rate of improvement. 16.7% of topics have a positive effect on the HSQ, among which *Service Rapidness* and *Maternity Unit/Treatment* have the largest increase in the number of positive comments.

Fifth, students may identify the influencing the *Hospital Ownership* on more positively and more

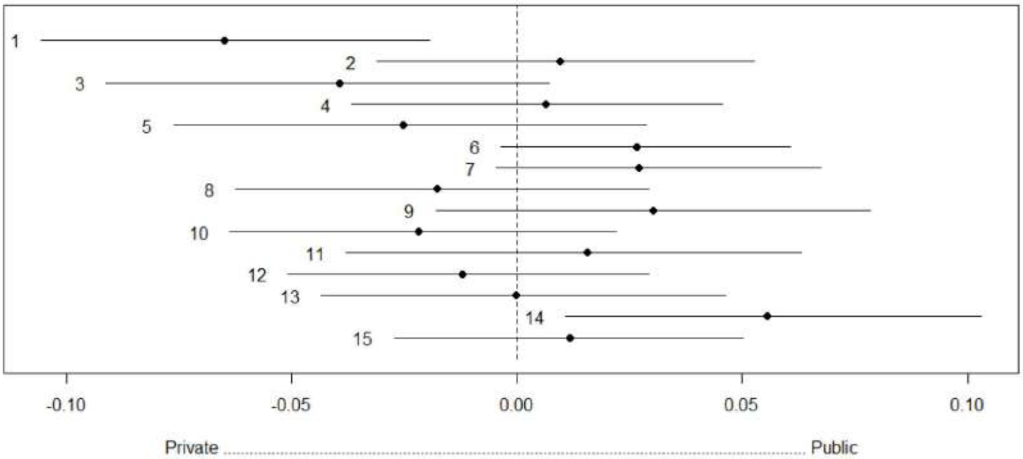

Figure 8: Difference in the power of Hospital Ownership influence on Topic Proportion.

negatively oriented HSQ aspects structure (using the Sentiment and Hospital Ownership factors as in the Covariates STM model). For this purpose, the following interpretation of the results could be proposed: (1) the Topics, more related to Public Hospital Ownership according to the results of effect estimation, in which the proportion of this Topics in comments about Public hospitals (Hospital Ownership = Public) is significantly higher than in comments about Private hospitals and vice versa; (2) the direction (positive or negative) of Hospital Ownership influencing on HSQ. For reaching the first purpose, the Hospital Ownership effect estimation was performed for revealing the aspects in which the proportion of the comments about Public hospitals (Hospital Ownership = Public) is significantly higher than comments about Private hospitals and vice versa.

For formalization the rules for second purpose reaching, in terms of discovering the Influence of the Hospital Ownership on the Service Quality, the following groups of aspects proposed to be distinguished: (1) Topics causing the growth the level of patients satisfaction with Service Quality in Public hospitals: positive topics with a positive dynamic from Private to Public; (2) Topics causing the growth in the level of patients satisfaction with Service Quality in Private hospitals: positive topics with a positive dynamic from Public to Private; (3) Topics causing the growth the level of patients dissatisfaction with Service Quality in Public hospitals: negative topics with a positive dynamic from Private to Public; (4) Topics causing the growth in the level of patients dissatisfaction with Service Quality in Private hospitals: negative topics with a positive dynamic from Public to Private.

According to the results of our experiment, 8 Topics are more associated with Public Hospitals (right side of figure 8), and 6 Topics are more associated with Private Hospitals (left side of figure 8), and one topic (Topic 13) is for both types of hospitals. Based on received results, we can conclude that the four topics (one positive and 3 negative), which more characterize the Public Hospital Ownership are (1) *Service Rapidness* (positive); (2) *Food Service* (negative) (3) *Maternity Unit/Care* (negative) and (4) *Patient-Focusing Service* (negative). In turn five Aspects, which more characterize the Private Hospital Ownership (two positive and two negative) are (1) *Appointment Time Reliability* (negative); (2)*Service Standards* (positive); (3) *Staff Feedback/Explanation* (positive) and (4) *Hospital Environment* (negative).

Thus, this example of the use of STM modeling in teaching students shows how versatile and in-depth research can be carried out using data science. Presented examples demonstrate the nature of tasks and approaches which could develop students' technical and research skills in the public perception analysis. Such approaches also allow students to gain *practical experience* in the study and interpretation the influence of additional metadata, characterizing the comments authors, on differences in their opinions about events, companies, goods, and services.

6 DATA SCIENCE STUDY PROGRAMS IN ECONOMICS FIELD

Classical methods of statistical analysis, modeling methods, and data mining are used in economics. The analysis of data in these areas is aimed at the study of

Table 3: Data Science courses and programs for economics at top-20 universities.

University	Location	Programs, courses
Massachusetts Institute of Technology (MIT)	United States	MicroMasters Program in Data, Economics, and Development; Policy Computer Science, Economics and Data Science – course
Stanford University	United States	M.S. in Statistics: Data Science; Tackling Big Questions Using Social Data Science – course
Harvard University	United States	Data Science for Business – course; Using Big Data Solve Economic and Social Problems – course
California Institute of Technology	United States	Business Analytics – course
University of Oxford	United Kingdom	MSc in Social Data Science
ETH Zurich - Swiss Federal Institute of Technology	Switzerland	Data Science in Techno-Socio-Economic Systems – course
University of Cambridge	United Kingdom	Economics: Data Science and Policy – course
Imperial College London	United Kingdom	MSc Business Analytics
University of Chicago	United States	Economic Policy Analysis – course
UCL	United Kingdom	Economics and Statistics BSc; Social Sciences with Data Science BSc
National University of Singapore	Singapore	Master of Science in Business Analytics
Princeton University	United States	Statistics and Machine Learning – course
Nanyang Technological University	Singapore	Master of Science in Analytics
EPFL	Switzerland	Master's program in Data science
Tsinghua University	China (Mainland)	Master's Program in Data Science
University of Pennsylvania	United States	Master of Information Systems Management, Business Intelligence and Data Analytics; MS in Information Technology, Business Intelligence and Data Analytics; Online Master of Science in Business Analytics
Yale University	United States	Applied Econometrics: Politics, Sports, Microeconomics; Applied Econometrics: Macroeconomic and Finance Forecasting
Cornell University	United States	Introduction to Data Science – course
Columbia University	United States	Data Science for Social Good – summer program
The University of Edinburgh	United Kingdom	Statistics with Data Science MSc

causation. In economics, current issues include policy development, determining the impact of a decision, long-term and short-term planning and forecasting, choosing the best solution from many possible, and many others. Drawing conclusions is also important in economics. In addition, the modern economy and finance are characterized using big data, so it is not always possible to use classical methods. Therefore, the methods of data science are precisely those methods that should be used in economics, which gives positive results and effect. Data Science methods were first used in economic research and gradually penetrated into practice. Today, economics need specialists who have knowledge in these areas and are able to apply Data Science methods. In response to this market need, universities have begun to implement Data Science courses and programs for students of economics. The table 3 presents the courses and programs of the top 20 universities in the world.

A study programs in economic field in Ukrainian universities has shown that Data Science courses and programs are still being introduced in Ukraine. Currently, there are separate programs for studying Data Science, mainly for computer science. Therefore, we believe that the prospects that Data Science opens for modern economists necessitate the introduction of courses and programs in Data Science.

7 CONCLUSIONS

Data science annually extends to more and more areas is used in various areas of research, in society, and in business processes. Businesses and governments are making huge investments in this area. Education, accordingly, must keep pace with the times and teach students new modern technologies. However, as research has shown, the process of studying Data science for economists is at an early stage. Leading universities are gradually introducing new courses and programs to study Data science in economics, but this phenomenon has not yet become widespread and needs to be developed.

As an example of the implementation of Data science methods, we have shown the use of STM-modeling in teaching students. The application of such approaches promotes the development of technology and research skills of students, demonstrates work with big data, and allows to gain experience in studying and interpreting the influence of additional metadata characterizing the authors' comments on differences in their opinions about events, companies, goods, and services.

The described methods and algorithms are just some of the basics of modeling and analysis of economic processes. There are many examples of how all these methods can be used in education. For example, using time series analysis, we could predict the future value of a cryptocurrency, using regression models, we could determine customer loyalty or the likelihood of customer insolvency, and so on. Today, there are many more algorithms that can be applied in economics.

Education must meet the modern development of the digital economy, digital society, innovation, and creative entrepreneurship. The use of Data science in education should be multi-platform, ie used not only in the study of the subject but in the teaching of all subjects, interaction of students with each other and with teachers, real experts, research, and individual learning.

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Integration of Modern Higher Education into the Global Information Space

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Keywords: Informatization of Education, Modern Higher School, Computerization of Education, Information and Communication Technologies, Goals of Informatization of Education, Distance Education, Integration of Education.

Abstract: This article focuses on the special importance of informatization of education as the main aspect of the existence and development of modern higher education. Emphasis is placed on the importance of informatization of education, because the informatization of education is the main driving force for the integration of modern higher education in the global information space. The process of computerization of education is considered as the main basis of its informatization in the historical aspect. The importance of the introduction of information and communication technologies in the educational process of free software and the interest of scientists in this field of education is emphasized. The interest of modern scientists in consideration of such problems as application of information and communication technologies in training is analyzed; problems of informatization of education and goals of informatization of education; didactic and psychological aspects of application of information and communication technologies in educational process; problems associated with the widespread introduction of information and communication technologies in higher education and informatization of education in general. Emphasis is placed on the importance of acquired skills and abilities acquired as a result of informatization of education and introduction of information and communication technologies into the educational process. The goals of informatization of education of a modern higher educational institution are determined. The priority goals of informatization of education are singled out. The types of education that are directly related to information and communication technologies are considered. It is noted that the practice of introducing information and communication technologies in the educational process of higher education institutions is spreading every day and brings only positive results. The importance of free software during the COVID-19 pandemic is described, as GNU-licensed systems are used to organize distance learning. The conclusions emphasize the relevance of this study. It is noted that educational activities based on the use of information and communication technologies are the basis for changes in the structure of the educational process for both teachers and learners.

1 INTRODUCTION

Currently, informatization of education is the main factor in the existence and development of a modern higher education, because its primary objective is the development and growth of the potential of each individual. Informatization of education is a set of interrelated organizational and legal, socio-economic, educational, methodological, scientific-technical, industrial and management processes. These processes are aimed at providing information, computing and telecommunication needs (other needs related to the implementation of methods and tools of information and communication technologies – ICT) of participants of the educational process, as well as those who manage and maintain this process (including those who provide its scientific and methodological support and development) (Bykov, 2010). Informatization of education increases the efficiency and intensification

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of the educational process by using information technologies and implementation of new methodological developments in learning process (Velychko, 2017).

The foreign policy of the state has several components. One of the components of which belongs to international relations in the field of education. The main goal of Ukraine's international activity in the field of education is integration into the world educational community as an equal partner. Such a partnership will enable the national education system to improve all areas of education through the practical use of international experience.

The Law of Ukraine "On Higher Education" states that one of the principles of state policy in higher education is the integration of higher education in Ukraine into the European Higher Education Area, provided that the achievements and progressive traditions of national higher education are preserved and developed (Verkhovna Rada of Ukraine, 2014). Another important factor is that Ukraine, in terms of population and territory, is one of the largest European countries, and therefore its role in the global integration processes of interdependence of the modern world is very important.

Considering the goals of informatization of the educational process of higher education, we identified a number of problems associated with legal, economic, educational, methodological, and scientific and technological processes. Implementation and application of ICT in the training of future professionals will play an important role not only as a tool for the disclosure and development of individual abilities of the individual, but also as a catalyst for comprehensive informatization of society.

ICT in education are part of pedagogical technologies aimed at the establishment of knowledge and the acquisition of acquired skills and abilities that, under the slightest effort, can be adapted to the individualities of any person who wants to study.

According to Velychko (Velychko, 2017), the use of information and communication technologies in educational activities will enable future specialists to use a wide range of modern methodological approaches and technologies and will help to reveal their inner creative potential, become a "visual guide" to the skills and abilities of information and communication technologies use to achieve higher learning results.

Many studies are devoted to the problems of informatization of education and the purposes of informatization of education. The most significant of them are (Bykov, 2010; Lapchik, 2013; Rakov, 2005; Zhaldak, 2013). Theoretical aspects of the application of ICT in education are reflected in (Semerikov, 2009; Soldatkin, 2003; Spirin, 2007; Zhaldak and Khomik, 1998). Conceptual pedagogical provisions, issues of e-learning didactics are reflected in (Andreev, 2013; Khutorskoi et al., 2013; Kukharenko et al., 2016; Vlasenko et al., 2020).

The problems associated with the widespread introduction of ICTs in higher education institutions and informatization of education are considered in (Hurevych et al., 2012; Hurzhii, 1998; Kiianovska et al., 2014; Manako and Sinitca, 2012; Morze, 2003; Tryus, 2010; Velychko, 2017).

The integration of higher education in Ukraine into the European educational space and the implementation of this process are considered in (Astapieva, 2020; Burdonos, 2015; Marichereda et al., 2020; Rayevnyeva and Stryzhychenko, 2018; Zheliaskov et al., 2020).

Modern education requires the variety of the forms, methods and techniques of the organization of educational activities. The preference should be given to the forms, methods and techniques that use information and communication technology, which can personalize the process of learning, enrich the acquired knowledge and allow individuals to become effective in professional activities (Velychko, 2017).

The introduction of the latest ICT into the educational process will accelerate the realization of such an objective as informatization of education.

Currently, it is possible to share the features of this process from the experience of other countries such as the United States, South Korea, England, Finland, Estonia, Ireland, Bulgaria, Germany, Switzerland and others (Kiianovska et al., 2014). Such experience gives modern scholars a clear understanding of the integrity of building a system of informatization of education through the introduction of ICT in the educational process of institutions of higher education.

The *purpose of the article* is to emphasize the importance of introducing information and communication technologies in the educational process of higher education institutions, emphasizing the special importance of informatization of education as the main aspect of integration of modern higher education into the global information space.

Research methods are: analysis of publications on the problems of informatization of education, the use of information and communication technologies in education; review of the contribution of higher education to the formation of the global information space and the transition to the information society; systematization and generalization of research information.

2 RESULTS

The state sets specific goals for higher education. The structure of the action plan and a clear course in the humanities determines the increasing role of higher education and science as the basis for Ukraine's effective "knowledge economy" (an economy in which most of the domestic product is provided by production, processing, storage and dissemination of information and knowledge). This is also stated in Article 10 of the Law of Ukraine "On the Principles of Domestic and Foreign Policy" (Verkhovna Rada of Ukraine, 2018).

Integration of modern higher education into the global information space is one of the priority tasks of modern Ukraine. The strengthening of society as an information state has become dependent on new knowledge, the effective transfer of information through higher education and vocational training systems. The use of information and communication technologies becomes indispensable in this process. Innovations in the tools of creating, disseminating and using knowledge have acquired new significance. Intellectual achievements become the most important product. At the heart of this strategy is a knowledge and skills management system.

Ukraine's course towards European integration requires qualitative changes in the field of science and education. Dynamic integration into the European higher education area will give the state an important link in this structure. However, active changes in the modern world require the development of new mechanisms of cooperation, taking into account the rules of interdependence and the creation of conditions for the adaptation of Ukrainian legislation to the requirements of the European Union. One of the priority areas of Ukraine's internal and external socio-economic and political strategy is its entry into the single European information and cultural environment. The exchange of graduates of higher education institutions of Ukraine with graduates of the European Union guarantees not only the integration of the education system into the European space, but also entry into the world information space.

The information space is a separate phenomenon. It is based on a set of databases, technologies for the use of information and telecommunications systems. Operation is carried out through the use of common principles and general rules, which provides information interaction. Each state has its own information space, regardless of the form of government. The content of the information space depends on such factors as territorial, technical, economic, human, etc. The boundaries of the information space are identified with the geographical borders of the country, covering the national territory and all spheres of society.

The information space consists of several components, one of which is the informatization of education.

Informatization of education is aimed not only at the formation of knowledge, but centered on the person who can apply the acquired knowledge and skills to work with information resources for successful activity in any sphere of public life and for the innovative development of society (Bykov, 2010). The level of innovation development of society directly depends on the level of informatization of education. Informatization of society is a process of education and establishment of each individual of a new generation in conditions of qualitative improvement of modern information and technical structures and processes created for the satisfaction of needs and the realization of life existing rights of a modern citizen (Teplitckii et al., 2004; Teplytskyi and Semerikov, 2005).

The basis of the process of informatization of education is the process of computerization of education, which started at the beginning of the XX century. In general, the process of computerization of education (Bykov, 2010; Morze, 2003; Velychko, 2017) is divided into three stages, but the initial date varies from the 20-ies XX century to the 50-ies of XX century. So, for example, Serhiy O. Semerikov, determined the beginning of the first stage is exactly the 20-ies of XX century. According to him, the first stage (20-50th years of the twentieth century) is described as the period of application of mechanical, electromechanical and electronic individualized devices (Semerikov et al., 2019; Modlo and Semerikov, 2017), with which the teaching material was provided and the control and self-control of knowledge were implemented – the technology of programmed learning. The second stage (50-80s of the twentieth century) is characterized by the wide introduction of computers into practical training activities. And the third stage (since the 80s of the last century) is specified as the stage of personal computers and computer networks (Semerikov, 2009).

Informatization of education is inextricably linked with existing learning models. In the 1950s and 1960s computer technologies were actively used in the implementation of the theory of behaviorism. The cognitive model of learning inherent in the 70-80s was used to develop critical thinking. Constructivism of the 90s with the use of computer technology solved the problem of changing personal relationships and building a social model. Modern information technologies have enabled the development of a new learning model – connectionism. Connectionism is evolving due to modern trends – distance education, mobile learning, mass open online courses, e-education and cloud technologies (Teplytskyi et al., 2015).

It is important that the entire initial stage of the development of informatization, which involves the development of computers and software related to universities. The development of computer technology needed highly skilled specialists who were trained directly at universities where the first computers were built (Velychko, 2017). Informatization of education is definitely connected with the development of material and technical bases and the preparation of complexes of educational methods for their use. A significant factor in the delay of the development of informatization of education, as well as the informatization of society as a whole, is the lack of sufficient financing of these projects by the state. That is why groups of programmers created free distribution software (Striuk et al., 2012). Thanks to these software products, teachers have had more opportunities to use computers in the learning process, which gradually led to the widespread use of ICT in educational activities which resulted in the informatization of education (Teplytskyi and Semerikov, 2003). The first software products used in university education belonged to open software as there was no global software commercialization. It should be noted that such software had limited scope and was used primarily for mathematical calculations.

The use of free software in preparation at the present level of informatization of educational activity plays a special role in preparation and in the formation of a scientific outlook, understanding the essence of practical orientation of informatics disciplines. The main objective of introducing of free software lays in the formation of a new citizen of the information society, who feels comfortable in society, freely operates with information through new information technologies, respect the opinion of others and has his own opinion and knows how to deliver it, is capable of self-education, self-analysis and has a motivation to obtain new knowledge and to self-improvement, while also understands the importance and inevitability of information education and society at large, giving preference to the latest information and educational technologies (Velychko et al., 2018).

Further evolution of informatization of education, which took steps from equipping educational institutions with electronic computers of the first generation to the application of the most modern tools of ICT, reflects both the achievements of scientific and technical progress. Cybernetics, computer science, IT industry, and achievements in the appropriate training of teaching and management education, computer level oriented scientific and methodological support of the educational process, automated systems of education and training led to the widespread introduction of ICT in educational practice (Bykov, 2010). Consequently, ICT are rapidly being introduced into the educational activities of higher education institutions and step by step, with the help of graduates of higher education, mastering other branches of education such as secondary schools, technical schools, schools, etc.

Through the use of ICT in education, all those who had not previously been able to afford it were given the opportunity to study and gain knowledge and skills in a variety of categories and areas. For example, people with special needs for whom, having regard to their physical condition and state of health, previously, higher education was not an achievable dream, now due to existing technologies and developed methods, they are able not only to acquire knowledge, but also desired diplomas.

Currently, there are many types of education directly related to ICT. Such types of learning as distance learning, e-learning, mobile learning, blended learning, etc., expand opportunities and choices for anyone who wants to study or improve their own qualifications or receive additional education. These opportunities are associated with the emergence of new, virtually unlimited pedagogical opportunities that have arisen as a result of the introduction of ICT in education and successfully used. For the individualization and differentiation of the educational process the use of additional information educational resources resulted in a wide range of pedagogical methods and technological training options. Changes in the nature of educational communications are increasing the procedural and multimedia characteristics of study and the expansion of the space of innovative pedagogical activity (Bykov, 2010).

These different emphases reflect the expected but also the unexpected impacts of the introduction of these digital technologies in the learning process. In the history of E-learning, initial definitions were more device-driven (focusing in immediacy, convenience, access and mobility) while the latter ones are more personal and social-driven, exploring affordances that relate to new technological features of mobile devices such as location awareness, motion detection and augmented reality (Pedro et al., 2018).

In the context of the latest world events related to the COVID-19 pandemic, such a form of e-learning as distance learning has received special attention (Bobyliev and Vihrova, 2021). It should be noted that the best learning management systems used to organize and support distance learning are created under free software licenses. Today, free software products have become widely popular in Ukraine due to limited funding for all areas of education. In essence, distance education is an individualized process of transfer and acquisition of knowledge, acquisition of skills and abilities, which occurs through the indirect interaction of distant participants in a specialized environment created on the basis of modern psychological, pedagogical and information and communication technologies (Verkhovna Rada of Ukraine, 2013), organization of the educational process on the basis of information and communication technologies based on the principles of independent work. Distance learning is individual process of gaining knowledge, abilities, skills and the ways of personal cognitive activity, occurring mainly at the mediated interaction of the participants of the training process, being distant from one another, in the specialized environment, functioning on the basis of modern psychological-pedagogical and information-pedagogical technologies (Syvyi et al., 2020). This form of education is progressive, because it provides more freedom and flexibility, promotes the development of individuality, allows learning incognito, helps to get education to anyone. Currently, several systems are used to organize distance learning: the well-known course management system Moodle, and its lesser-known, but no less important and full-fledged systems ATutor, Claroline, Dokeos, ILIAS, JClic, LAMS, OLAT, OpenACS, Sakai are not inferior in functionality to proprietary software from IBM, Oracle and others and comply with the Tin Can API (successor to the SCORM standard) that exists for distance learning systems. The listed software products (Moodle, ATutor, Claroline, Dokeos, ILIAS, JClic, LAMS, OLAT, OpenACS, Sakai) belong to the free software.

The main advantage of Moodle distance learning system is the possibility of its free using. At the same time, the functionality of the distance learning system in the Moodle system is not inferior to commercial analogues. Another important advantage of the distance learning system Moodle is that it is distributed in open source, which allows you to adapt it to the specifics of the tasks that must be solved with its help (Tarasov et al., 2020). The advantage of such training is the emergence of opportunities for students to perform training tasks in any convenient place and in their spare time. In addition, the use of modern computer technology in the learning process allows you to get skills that will be useful in work and everyday life. The system also provides the ability to test their knowledge by testing, which makes more effective using of electronic learning materials.

The use of ICT to create distance learning courses creates new requirements for both the methodology of using the software and the software itself.

By scientists and researchers definition there is a classification of pedagogical software tools, based on which pedagogical orientation that is the realization of certain didactic functions in the learning process (Velychko, 2017):

- demonstration programs (designed for a demonstration of the training material of a descriptive nature);
- training programs (aimed at the acquisition of new knowledge; implemented usually in the form of a dialogue);
- simulators (provide the formation and consolidation of practical skills, and also used in self-education activities);
- control programs (designed to control a certain level of knowledge and skills. Application of such programs enables to increase the efficiency of training, to intensify and increase the productivity of the teacher, provides the necessary stability and invariance and independence from subjective teacher settings);
- simulation and simulation programs (allowing to simulate objects, phenomena and processes of the real world. Their effectiveness is achieved when the process or the phenomenon cannot be practiced (micro and macro world). In the process of using such programs, abstract concepts become more specific and easier to perceive by those who learn);
- information and reference programs (intended for search and output the necessary information for educational, methodological and other purposes. Such programs include electronic encyclopedias, knowledge bases. Today the value of their application is to organize access to information through modern telecommunication networks;
- programs for problem learning (designed to activate cognitive activities of students through the formulation of various problems and tasks that need to be resolved through attempts and errors).

The practice of introducing ICT in the educational process of higher education institutions is spreading every day. Many software products, methods and technologies used at the beginning of the informatization of education have undergone many changes and updates, new ones have appeared. Currently, information and communication technologies are rapidly being introduced into the educational process of higher education institutions. If the first implementations concerned the use of software products for purely mathematical calculations and in the teaching of disciplines of the mathematical cycle, now this range is almost limitless (Markova et al., 2018). Educational software products are used in the teaching of all disciplines, from psychology and law to philology, physical education and music. And the wider the range of different software used within a given discipline, the greater the benefit to learners as they gain new functionality, which significantly affects the learning process and is more useful in achieving certain goals.

ICT are innovative pedagogical technologies of the education system used to create new opportunities. The transfer of knowledge (the activities of the teacher), the perception of knowledge (the activities of students), the assessment of the quality of education and the comprehensive development of personality during the educational process (Zakharova, 2013), makes the educational process more intense and productive through the use of multimedia capabilities, intersperses interpersonal communication provides the search for information from various sources, creates convenient circumstances for communication in the most appropriate form (Syrovatskyi et al., 2018).

Modern teaching methods involve the use of information and communication technologies in the educational process. The use of ICT has not only changed the methods of traditional learning, redistributed priorities between forms of learning, but new forms of learning have emerged. For any method or form of training that uses high information technology, software is required, without which the technologies lose their meaning (Fedorenko et al., 2020).

Scientists paid much attention to the use of ICT in education and described in their doctoral dissertations. So, for example, it is noticed that a computer science teacher with fundamental knowledge in the field of informatics is needed even in secondary school (Lapchik, 2013); the main goal of computer science students is the formation of professional informational competencies, which are based on public order, state higher education standards and personal choice of a student, the function of fundamentalization of informatics education is the basis for the formation of new qualities of a future specialist (Semerikov, 2009); vocational guidance function of the fundamentalization of informatics education has the following structural components: target, content, technological and the final ones (Morze, 2003); multimedia in education – a promising direction in the field information processing of human activity, integration of heterogeneous data computer systems in order to more fully present the results of intellectual production in science, art, education, industry etc. (Anisimova, 2002); informative awareness – the ability to implement the systemic knowledge, skills and abilities of acquiring and transformation of information in various fields of human activity for the qualitative performance of professional functions and conscious prediction of the consequences of its activities (Petukhova, 2009); informational competence includes the ability to independently search, analyze and select the necessary information, organize, transform, store and transfer it using real objects and information technologies (Khutorskoi et al., 2013). Digital competence is the main component of the information culture as part of the overall culture of the individual (Zhaldak and Khomik, 1998; Kuzminska et al., 2019; Moiseienko et al., 2020); information culture is a collection of informational worldview, systems of value orientations, knowledge, skills, providing purposeful and effective independent activity with the purpose satisfaction of own and professional needs in information products (Kolomiyets, 2008); informatization of education is one of the most important elements of culture in general, characterizing the material and spiritual development of society, the level of organization of information processes, the degree of satisfaction of the needs of people in informational communication, timely, reliable and exhaustive information and provides a coherent vision of the world (Zhaldak and Khomik, 1998); the use of ICT in education includes skills and work skills in the information and communication pedagogical environment, the ability apply multimedia teaching aids for the tasks of professional activity, the ability to use knowledge control with the help of a computer, the ability to use ready-made electronic tools and independently develop their own multimedia teaching aids, forms Internet communication skills (Kolomiyets, 2008) and many other works devoted to informatization of education and the use of ICT in education.

Informatization of education is stipulated by branch directions. Considering the goals of informatization of education Bykov (Bykov, 2010) noted that at the present stage of development of society and education the main goal is to prepare those who are studying for active and productive life in the information society, to provide high-quality, affordable and effective education, to create educational conditions for life-long learning at the expense of widespread introduction into the educational practice of methods and means of ICT and computer-based technologies. Informational education provides two strategic goals. The first of these is to increase the efficiency of all types of educational activities through the use of ICT. The other is in elevation the quality of training specialists with a new type of thinking that meets the requirements of the information society (Kryvonos, 2012).

Also, the issue of integration of modern higher education into the global information space and innovative teaching aids has not gone unnoticed by scientists. In the higher education sector, a new era has begun with the advent of ubiquitous learning environments. Ubiquitous learning tools allow improving context-aware as well as learning experiences by offering seamless availability regardless of location all the time. There are numerous available ubiquitous e-learning tools that can be employed in higher education. E-learning tools also offer training and higher education to many students that have different higher educational levels and come from diverse cultural backgrounds (Aljawarneh, 2020).

Responsibility for greater integration with the EU and removal of the Soviet legacy Consideration of the dichotomy between the EU and the Soviet legacy university management becomes increasingly important in view of a greater push from the Ukrainian public to create a European-type of university and become more effective members of the European space of higher education. Ukrainian institutional researchers need to seek greater integration of the EU criteria for development (Oleksiyenko, 2019).

In accordance with the current legislation, the Law of Ukraine on National program of informatization, the informatization means a set of interrelated organizational, legal, political, socio-economic, scientific and technical, production processes aimed at creating conditions for meeting the information needs of citizens and society through the creation, development and use of information systems, networks, resources and information technologies based on application of modern computing and communication technology (Verkhovna Rada of Ukraine, 1998).

Every teacher who works now and in the future should know that informatization of education is a modern resource getting answers to questions that are of interest to educators and students. Possessing skills using information resources is the major way of improving their own professional ability. And this is also one of the goals of education informatization.

For the primary goals of informatization of education we have to include the following components as:

- establishment of skills of self-education and self-realization;
- advancement of the potential of each person and its development;
- development of the educational spectrum of services for people with special needs;
- increase in the quality of education;
- formation of skills for building own educational trajectory;
- raising the fundamental level of general and education;
- creation of new special methods, tools and educational technologies;
- raising the level of pre-professional training of higher education students of general school;
- increasing the aptitude to analyze the extended knowledge and skills of students;
- expansion of methods and means of teaching using modern scientific and technical developments;
- providing favorable conditions for those wishing to upgrade their qualifications;
- development of postgraduate education and adult education;
- expansion of limits and possibilities of self-realization;
- establishment of the society with the informatively experienced population;
- development of the intellectual potential of the nation;
- enhancement and modernization of traditional forms of training curriculum.

The degree of informatization of education is a direct reflection of the level of informatization of society, which is why the information development of education becomes the major factor in the growth of the general level of training of students. Students develop skills to create and implement the latest technologies for future professional activity and form the theoretical basis of knowledge while studying at a pedagogical higher educational establishment.

Informatization of education is the main driving force for the integration of modern higher education into the global information space. Support for the informatization of education by the state is carried out through such actions as the adoption of the Law of Ukraine “On the National Informatization Program” (Verkhovna Rada of Ukraine, 1998), the Law of Ukraine “On Higher Education” (Verkhovna Rada of Ukraine, 2014), the Law of Ukraine “On Principles of Domestic and Foreign Policy” (Verkhovna Rada of Ukraine, 2018), The Law of Ukraine “On Scientific and Scientific-Technical Activity” (Verkhovna Rada of Ukraine, 2016), the Law of Ukraine “On Education” (Verkhovna Rada of Ukraine, 2017), the National Strategy for the Development of Education in Ukraine until 2021 (Verkhovna Rada of Ukraine,

2013) and others. Indeed, the priority of the state educational policy of Ukraine is to improve the infrastructure of the information educational space and, as a consequence, the creation of electronic educational resources of educational institutions. However, to solve this promising task it is necessary to overcome the problems associated with the imperfection of the legal framework governing this issue, the difficulties in creating electronic educational resources, the lack of clear coordination of all participants in the educational space.

It is important to understand that for the wide and full use of information and communication technology products in educational institutions it is necessary to create interest in the necessary changes not only in the state, but also in the educational environment. Creating an appropriate legal framework, increasing control over the use of software, adopting standards for electronic documents, the transition to the study of information and communication technologies are just some of the actions needed to address this issue.

It should be emphasized that Ukrainian researchers have conducted a lot of research on education funding. Such studies indicate that increasing government expenditures on higher education has a positive effect on the dynamics of GDP per capita. The analysis was carried out using R software. Four models were used for the analysis: pooling, random, with-in, and between. Data for analysis are available from World Bank and OECD data bases on tertiary educations expenditures. Data were organized as a panel data. The panel consists of indicators for twenty-seven countries for time horizon 2006–2015. The study includes mainly high and medium-income countries. Countries included into panel are Australia; Austria; Azerbaijan; Belarus; Brazil; Colombia; Czech Republic; Denmark; Estonia; Finland; France; Germany; Hong Kong SAR, China; Hungary; Ireland; Japan; Latvia; Lithuania; Norway; Poland; Portugal; Slovak Republic; Spain; Sweden; Switzerland; Ukraine; United Kingdom. The total number of observations amounts to 262 (Bilinets et al., 2019).

In today's world, knowledge has become a key force in social transformation in defining the model of learning, cultural development and change in the social structure of society. It is clear that the field related to the production of knowledge, methods of their production, processing and dissemination of information will always remain dominant in the information society. The intellectual potential of mankind and skills determine the pace of economic development and scientific and technological progress of society. A society based on information and knowledge about information is becoming the most promising model of social development.

Considering this question, scientists note that under globalization processes, the influence of the problem of interdependence between national education system efficiency and safety condition of the country is becoming more and more important. Now the aim of the countries is to provide competitive advantages on the international scene. The state of educational system and its potential plays the main role in this regard. Government safety is provided by all the means and resources which the government has. But amid them human resources occupy a special place. The role of education in national safety system is important as sustained development and support for possibilities of intelligent, economic, and industrial facilities on a high level, which is necessary to realize reliable satisfaction of requirements during the time of peace and war (Shestakova et al., 2017).

3 CONCLUSIONS

Based on the above and based on the fact that the integration of modern higher education in the global information space can occur through continuous updating of methods and informatization of education, and informatization of education is a major factor in the existence and development of modern higher education and society as a whole. that the informatization of education at all levels should become one of the main and important tasks of the state. As already mentioned, the informatization of education is the basis of informatization of society as a whole, which is why the problems of informatization of educational facilities should be given priority at both local and national levels. Informatization of education directly affects the content of education and methods of its organization, has pedagogical goals and objectives. Provides the necessary conditions for the integration of the educational system of Ukraine into the world information space. Learning activities based on the use of information and communication technologies become the basis for changes in the structure of the work process of teachers and forms a new perception of educational material by learners, influences the development of self-education through information learning resources and thus gain experience in using ICT future professional activity. Widespread introduction and application of ICT in education is the key to the development of scientific research and development. The quality of educational software products is improving. There is a continuous development of pedagogical technologies based on ICT. New training courses and methods, as well as various forms and technologies of teaching are being developed and implemented in the field of education. Given the attention paid by scientists and researchers to the informatization of education, the introduction of information and communication technologies in the educational process at all levels and in all fields of education, we can conclude that the informatization of education is a constant process of development, quality of life and education, the growth of forms and methods of teaching.

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Digital Technologies in Specialized Mathematics Education: Application of GeoGebra in Stereometry Teaching

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Keywords: GeoGebra 3D Graphing Calculator, Geometry, STEM Competencies, Stereometry Teaching, Methodology of Teaching Mathematics, Cloud Technologies in Education.

Abstract: The purpose of the paper is to improve methodology of teaching Mathematics via the use of digital technologies. The task of the paper is to identify the issues that require a theoretical and experimental solution. The objective of the paper is the educational process in the higher education institution, the subject of the paper is modern ICT. The result of the study is the learning tools of pedagogically considered and adequate bending of conventional and modern learning environment implemented into the educational process. The possibilities of using cloud technologies and Dynamic Mathematics system GeoGebra in the educational process through Stereometry specialized training have been revealed. The use of GeoGebra Dynamic Mathematics in Stereometry teaching will favourably influence the formation of students' STEM competencies. In order to encourage Mathematics and Computer Science teachers to implement effectively the elements of STEM education, it is suggested that cloud-based learning tools such as GeoGebra be used in the teaching process.

1 INTRODUCTION

Velikova and Petkova (Velikova and Petkova, 2019) point out that every society needs STEM professionals, talented people who design new technologies, materials, constructions and processes. One of STEM training related fields is an integrated problem-based Mathematics training.

The results of the research study regarding the development of teachers' STEM competencies have shown that most of them are not aware of the peculiarities of students' STEM competencies formation. And some contradictions between the necessity to form the students' STEM competencies and insufficient attention to the training of future teachers of Mathematics occur.

One of the most effective tools for STEM-based Mathematics teaching is the system of dynamic mathematics, e.g. GRAN 2D tool and cloud-based GeoGebra. Lavicza et al. (Lavicza et al., 2020) claim that GeoGebra was designed to integrate arithmetic, algebra, geometry, calculus, statistics. In recent times it is supposed to support STEM subjects as a single, integrated system available on most technology platforms. Moreover, teachers and students are offered free access to it all over the world. GeoGebra was originally created to integrate Algebra and Geometry into a single environment. GeoGebra enables to use such new technologies as Augmented (Striuk et al., 2018) and Virtual Reality (Lavrentieva et al., 2020), 3D Printing (Hevko et al., 2020) and MID (Modlo et al., 2019) in the learning Mathematics.

The use of GeoGebra Dynamic Mathematics in Stereometry teaching will enhance the formation of students' STEM competencies. It can also be helpful in the formation of key mathematical and digital competences (Astafieva et al., 2020; Moiseienko et al., 2020), self-study competences, as well as in the development of spatial thinking.

In order to encourage Mathematics and Computer Science teachers to implement the elements of STEM education, it is suggested the cloud-based learning tools, such as GeoGebra, be used in the learning process.

The 3D Graphics application (3D feature graphs, surface, and 3D geometry) can be used while develop-

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ing the visuals with AR. The application is now available not only for users of gadgets in the iOS operating system, but also for Android version 4.0 and higher. This program includes some examples of 3D mathematical objects that can be placed, such as on a desktop, floor, or any other flat surface. The fixed models will be managed. They can be resized. Such visualization will allow you to see more mathematics in the surrounding world.

More detailed information about the application 3D Graphics can be found in our article (Kramarenko et al., 2019b), teaching aids visualization during lectures and practical classes, in particular in Mathematics, allows students to understand the learning material better, to increase the applied orientation of learning and the communication competence both learners and teachers.

Gartner attributes Artificial Intelligence Education Applications, Conversational User Interfaces, Blockchain in Education, Immersive Technology Applications in Education, Design Thinking, Competency-Based Education Platforms and Adaptive Learning Platforms to the main tendencies of using ICT in education (Panetta, 2019).

Since augmented reality technology already has an important place in innovative development, it can also have significant potential for implementation in Mathematics learning. That is why this technology needs more detailed study. Because augmented reality is intrinsically linked to 3D construction, its usage in conjunction with Dynamic Mathematics systems like GeoGebra, can significantly increase the level of visualization in Mathematics and enhance students learning. In addition, Augmented Reality can become a tool for enhancing STEM-based learning for students majoring in Mathematics and Computer Science.

2 LITERATURE REVIEW

According to the recommendation of the European Commission (EC, 2018), competence is defined as a combination of knowledge, skills and attitudes. In the updated list of key competences of a personality eight major ones are emphasized (EC, 2018). We are keen to foster the development of students' STEM competencies: mathematical competence and competence in science, technology and engineering.

Rakov et al. (Rakov et al., 2009) explores the possibilities of mastering mathematical competencies in the learning by future teachers through the research approach using the system of dynamic mathematics DG. The scientist distinguishes procedural, logical, technological, research and methodological competencies of Mathematics teacher. In particular, methodological competence implies the ability to assess the appropriateness of using mathematical methods to solve individual and social issues.

Consider in detail the opportunities which GeoGebra gives to a teacher. Hohenwarter et al. (Hohenwarter et al., 2008) emphasize a significantly important role of free open-source software for teaching mathematics world-wide. Open-source software do not only offer opportunities for teachers and students to use them both at home and in the classroom without any restrictions, but they also provide the tools for developing support and user communities reaching across borders. Such collaboration as well contributes to the equal access to technological resources and democratization of learning and teaching mathematics.

GeoGebra is available in multiple languages. Using GeoGebra a teacher can create interactive materials to solve the main tasks of teaching Geometry – the development of spatial imagination, practical understanding and logical thinking.

GeoGebra can be used both in standalone and online modes on mobile Internet devices (MID) which offer new opportunities to improve learning and teaching either inside or outside of classrooms. Further advantage of GeoGebra is the Resources tab containing a number of teaching materials: textbooks, articles, instructions, and illustrations. Also, a registered users can share their own educational materials on the official website via GeoGebraTube (this is a kind of file-sharing site). Its essential feature is that the created dynamic constructions can be accessed online via the use of View Sheet tool. Any user is allowed to comment on GeoGebraTube content.

A user is provided with a possibility to create their own GeoGebraBook, a folder where selected materials can be added and subfolders can be created. A user can publish a game, a collection of visuals, lesson workbook that may include text messages, GeoGebra models, web pages, questions, videos, images and manuals public to anyone. GeoGebraTube content can be shared via social networks Facebook, Twitter, emailed and uploaded to Google Drive. Cloud-based tools affect favourably teacher-student interactions in an informal learning environment.

Diković (Diković, 2009) statistically confirms the fact that the use of GeoGebra applications in learning calculus had a positive effect on the development of students' reasoning and visualization skills.

The issues of using GeoGebra are highlighted in (Drushlyak et al., 2020; Semenikhina, 2017; Semenikhina and Drushliak, 2014). Application of GeoGebra 5.0 to the solution of solid geometry problems has been analyzed in (Semenikhina and Drushliak, 2014). Examples of solid geometry problems with detailed solution and learning clues have been presented. Among them there are problems on auxiliary section, polyhedron net, locus problems, space transformations etc. Semenikhina (Semenikhina, 2017) discusses the relevance of the study of the dynamic Mathematics software for future teachers of Mathematics in Ukraine.

The purpose of study by Zetriuslita et al. (Zetriuslita et al., 2021) was to identify improvements in Self Efficacy and selfregulated through GeoGebra Based Teaching seen from the level of students' initial mathematical abilities. The research method used was a mixed-method with a sequential explanatory strategy, while the research design was an untreated control group design with pretest and posttest. the experimental group obtained direct learning using GeoGebra software while the control group obtained conventional learning. The population in this study were university students of mathematics education department at the Islamic University of Riau who took the field and space analytic geometry course. The research instruments used were self-efficacy questionnaire and self-regulated questionnaire for getting quantitative data and interview guidelines for getting qualitative data. It was concluded that GeoGebra based teaching was effective in improving students' self-efficacy and self-regulated. Judging from the level of students' initial mathematical abilities, there was an increase in self-efficacy and self-regulated through GeoGebra based teaching from both high, medium and low levels.

Modelling implies simplifying thus providing the model with its own characteristics, independent from the original reality. Consequently, geometry, in its interpretation and processing, acts like a new reality both abstract in its logic and concrete in its representation modes.

Richard and Blossier (Richard and Blossier, 2012) begin with classical theories of modelling representation processes in order to apply them to 3D dynamic geometry software, GeoGebra3D, computing development seeking to bring geometric models closer to the reality of a school setting. The authors introduce three key notions, developed from Mathematics teaching, in order to support the exploration of two interaction situations between mathematics and their teaching. Finally, they finish on a few general considerations for the teaching of mathematics.

A number of works of scientists and software developers are devoted to the research of integration issues of the augmented reality technology into the educational process. In particular, (Brzezinski, 2019; Striuk et al., 2018), focus on the general trends and special issues of the augmented reality application in education.

In teaching Stereometry, the assignment worksheets on the construction of sections through the trace method, internal projection and combination method by Sidoruk (Sidoruk, 2018) should be taken into consideration. Each of the assignments is provided with the possibility of step-by-step procedure of the construction building. Thus, students are given an opportunity to develop both mathematical competence and the ability to learn independently. Some assignments include constructions created on a 3D canvas.

Fariha and Lestari (Fariha and Lestari, 2019) describe in detail how to realize the Dandelin Sphere more realistically, using GeoGebra Classic 5, which supports the creation of 3D images.

At a profound methodological level, a number of assignments on combinations of geometrical solid shapes was created by Rykovskyi (Rykovskyi, 2018). These models are designed as constructions of plane geometric shapes through the use of parallel projection properties. They are intended to be used to visualize the properties of geometrical shapes. However, students might face a challenge with reproducing models as the algorithm of the construction and details of the construction are not available for them.

The models are designed as constructions of plane geometric shapes with the use of the properties of parallel projection. In particular, a book / collection of visuals covering the topic "Prism" is recommended. There is a number of visuals that represents combinations of stereometric shapes: sphere and pyramid, sphere and prism, sphere and cylinder etc. Consider the visual "There is a cone inscribed in the sphere. And there is the right triangular pyramid inscribed into the cone. A pyramid is inscribed in the sphere". Even the name itself suggests that integrity is inherent to visuals. It can be used in the process of teaching Stereometry in school or teaching Methodology of Mathematics on various topics. While using visual aids, users are advised to study the properties of shapes inscribed into the sphere, to look into the relationship between the sphere radius, radius of cone base, the height of the cone and element of the cone.

These visuals are equipped with the Checkbox tool which allows a user to do the revision and answer to the questions: Which cone is called inscribed into the sphere? What element of the cone is the center of the sphere? Which pyramid is called inscribed in the cone? Which pyramid is called inscribed into the sphere? How to find the axial section of the cone?

Which circle of the sphere is called a great circle? Which properties of the diameter of the sphere perpendicular to its great circle?

Mobile applications such as Geometry, Graphing Calculator, 3D Graphing Calculator have been relatively recently launched and now they are available on the official GeoGebra website. These applications are still undergoing improvements. However, the methodology of their use, and especially in teaching Stereometry, is not yet well developed. Therefore, this paper aims at elucidating the features of creating visuals with GeoGebra and their use in teaching how to solve Stereometric problems.

3 RESULTS

3.1 GeoGebraBook "Models for Stereometric Problems" as Training Manual on the Methodology of Teaching Mathematics

The methodical materials of the paper authors related to the use of the GRAN software are presented in the manual "Innovative information and communication technologies of teaching Mathematics". The issue of GeoGebra use has been considered in an updated version of the manual (Kramarenko et al., 2019a). On the GeoGebra site, users can find the materials which contain relevant visuals at GeoGebraBook "Models for stereometric tasks" (Kramarenko, 2019). One can find here problem situations to be solved by students independently, self-assessment tests.

The study of the effectiveness of the use of GeoGebra mobile applications in the process of teaching Stereometry was conducted by us within the preparation of future teachers of Mathematics during Mathematics teaching methodology classes, advanced training courses at Kryvyi Rih State Pedagogical University, in teaching students of Kryvyi Rih State College of Economics and Technologies, and students of classes with mathematical specialization of Kryvyi Rih schools.

Particular interest in using GeoGebra was shown during the advanced training courses by Kryvyi Rih teachers of Mathematics who have been working at school for a considerable time. The study was also conducted on the effectiveness of the use of GeoGebra applications by students in order to enhance students' motivation during extra-curricular vocational activities at the university. And it was studied as well during the course of Sereometry lessons conducted by masters majoring in Mathematics education completing professional practice in secondary education institutions.

When using applications, it is useful for a student to be able to reproduce the construction in the browser window, open other temporarily hidden drawing elements in case of necessity, and receive text notifications. However, a considerable number of constructions should be created later or simultaneously with the viewing via the mobile application.

Consider the peculiarities of the implementation of specific constructions and provide recommendations concerning their use.

One of the main issues that school students and students of higher education establishments face is the recognition of a 2D drawing representing the image of a 3D shapes. In order to develop the spatial imagination of students at schools and universities it is necessary to provide them with the assignments on constructing sections of polyhedron by planes.

3.2 Construction of Sections of Polyhedron With Plane via the Applications GeoGebra Geometry and 3D Graphics

Consider examples of problems for constructing a section of a polyhedron with a plane passing through three given points that are not on the same line; through a straight line and a point that does not belong to it etc. It is necessary to construct a linear angle of a dihedral angle and measure them; the angle between the straight line and the plane.

Look into what four approaches to constructing a section of a polyhedron in a plane which should be distinguished by a teacher in order to be able to provide their students with the most appropriate one for their educational trajectory (Kramarenko et al., 2020).

If a student has not fully mastered GeoGebra tools, it is advisable to provide them with a sheet of paper guiding the algorithm to follow in order to build a construction. Moreover, a student should be supplied with information regarding the icons that correspond to the tools in question. It is appropriate to place QR codes on printable worksheets for demonstrations.

1. The construction on a 2D canvas is rather cumbersome and requires logically justified steps for the construction. At first, it is necessary to follow step-by-step construction procedures to build several drawings, created via "the trace method" on a 2D canvas. To intensify the material dissemination, students may be at once provided with a constructed polyhedron. However, in the course

of the study, there were cases when the students constructed the polyhedron wrongly. That is, after its construction on the plane, they were not able to change it dynamically. For example, to build a prism image on a 2D canvas made of an *n*-sided polygonal base ($n > 3$), it is necessary to follow the following steps. Firstly one should build an *n*-sided polygon via the use of the appropriate tool. Then it is preferable to build a vector along one of the edges of the prism. Further, one should apply a parallel translation of the *n*-sided polygon to the constructed vector. The given vertexes are connected. Such a construction is represented taking into account the properties of the parallel projection.

2. Next it is necessary to compare the previous drawing with the one presented according to the same problem situation but on the 3D canvas. In this case, all straight lines for the construction of the section can be presented step by step. The advantages of such a construction include the possibility to change the constructed polyhedron dynamically and the location of points which the secant plane passes through. Via the GeoGebra 3D Geometry (GeoGebra Team German, 2018) app, one can simulate external actions aimed at geometrical solid shapes which are necessary for a student to be able to apply internal thinking regarding them and as a result develop spatial thinking. In our opinion, this approach is the most appropriate for the development of students' spatial imagination, logical thinking. In figure 1 the construction of the section of the prisms with a secant plane which passes through the point on the lateral edge and a straight line drawn in the plane of the base is presented.
3. The third option for constructing a section on the 3D canvas. Firstly, a polyhedron, and a secant plane should be built, and then the tool "Intersection of two surfaces" should be applied. A student, by "turning" the polyhedron, will have an opportunity for the better perception and understanding of the construction. The approach in question is appropriate when augmented reality tools are used enabling to align the drawings with the image of a real object (Kramarenko et al., 2019b). It is advisable to encourage students to find examples of such sections among the surrounding objects, in architecture etc.
4. The use of both 2D and 3D canvases simultaneously. Such a combination is advisable if there is some kind of difficulty in constructing a polygon that is for a base of the pyramid or specifying the position of the vertex of the pyramid, etc. For instance, if a trapezoid, in particular, a rectangular or equilateral one, is for a base of the pyramid or prism (figure 2).

It is worth pointing out that such constructions can only be built in the classic version of GeoGebra, and the construction preview may also be available via MID after uploading the file to the GeoGebra cloud repository.

3.3 The Peculiarities of the Definition and Angle Construction between Planes and Linear Angle of the Dihedral Angle

Via the assistant of GeoGebra (3D canvas) it is possible to build the base of the pyramid (OXY) on the canvas, and in the process the constructions can be synchronously displayed on the 3D canvas (figure 3).

Attention should be drawn to the convenience and ease of the construction with the help of the linear angle of the dihedral angle at the base. According to the definition, to determine the linear angle of the dihedral angle at the base a plane perpendicular to the edge of the dihedral angle should be drawn. Then the angle between the rays formed as a result of the intersection of this plane with the edges of the dihedral angle will determine its linear angle (Bevz et al., 2011).

It should be stated that the measure of the angle between the planes varies from $0°$ to $90°$. While the measure of the dihedral angle can vary from $0°$ to $360°$ (Rykovskyi, 2018). Here is an example of the problem from the textbook with major in Mathematics (No. 836, (Bevz et al., 2011)).

At the base of the pyramid there is an isosceles triangle with angle β at the vertex and radius R of the circle described. The plane of each face of the pyramid forms an angle α with the plane of the base. Find the area of the side surface.

It is recommended to use 2D and 3D canvases simultaneously to represent the drawing corresponding to the set problem (Kramarenko, 2019).

The reason why mistakes are often made is that only one case is under consideration. Whereas the concept of "angle between the plane of the lateral face and the plane of the base" is substituted by "dihedral angle at the base". If the problem situation said that "dihedral angles at the base were congruent", then we would consider the pyramid the vertex of which is projected into the center of the circle inscribed into the triangle of the base (Pyramid of Type 1).

Since it concerns only congruent angles between planes, the problem will have two solutions. It is also

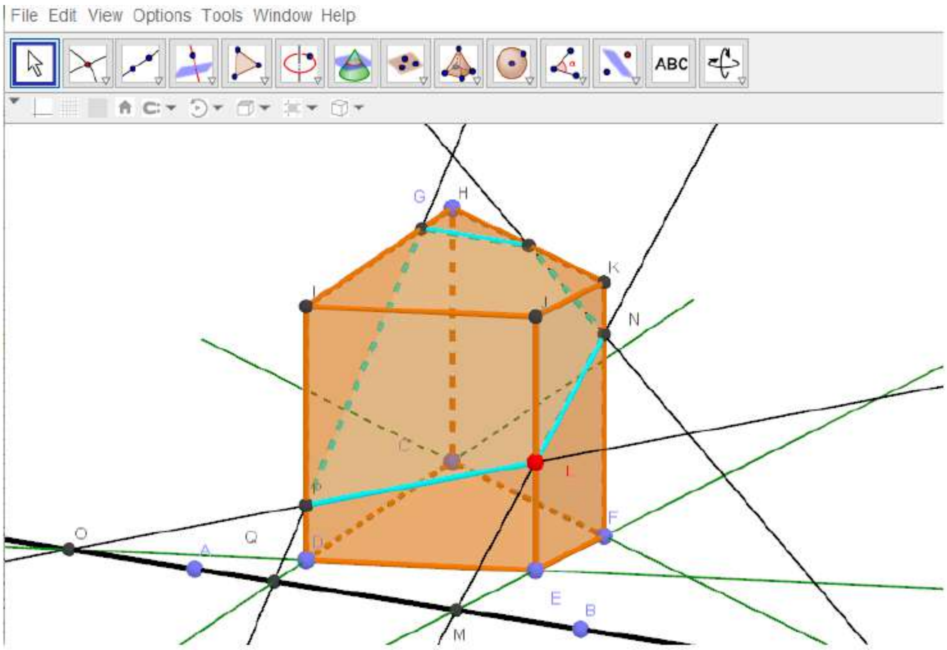

Figure 1: Construction of a section of the prisms with a plane.

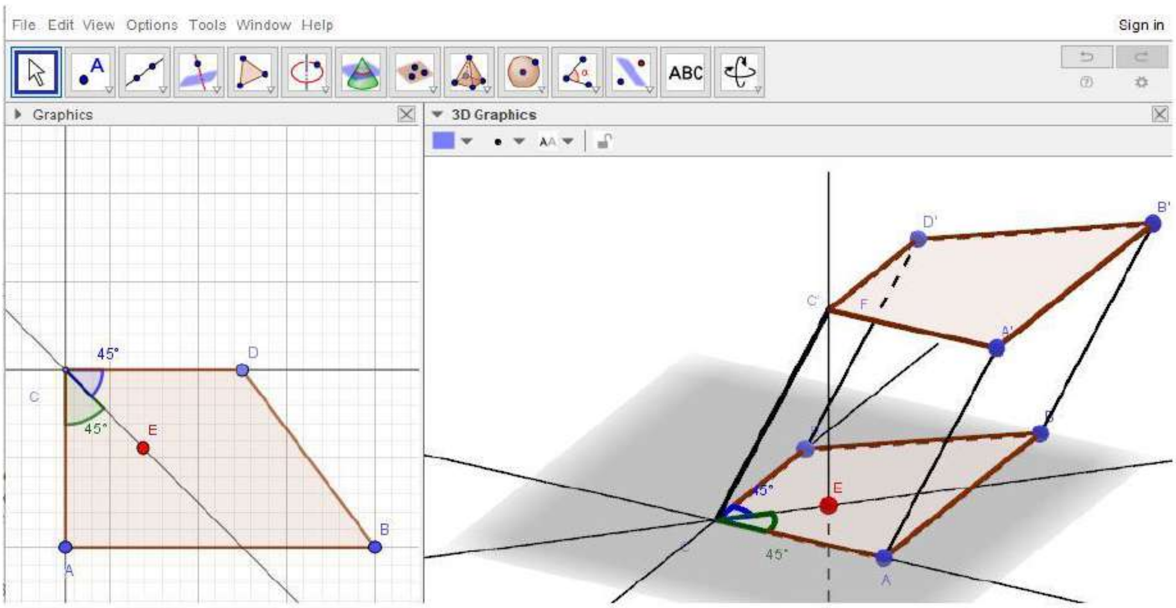

Figure 2: Construction of a prism, using both 2D and 3D canvas simultaneously.

necessary to take under consideration the case when one of the dihedral angles at the edge of the base is obtuse (Pyramid of Type 2). In this case, the vertex of the pyramid is projected into the center of the inscribed circle lying outside (figure 3).

Using the problem mentioned above and similar ones we have conducted a research on the basis of the two 11th grade classes specialized in Mathematics, and in particular with the teachers of Mathematics Svitlana Shakhmatova and Ruslan Kaluhin (Kramarenko et al., 2019a). 16 students of the experimental group (EG students) and 18 students of the control group (CG) have participated in the research. The similar research has also been conducted at the advanced training courses among the teachers of Mathematics in Kryvyi Rih State Pedagogical University

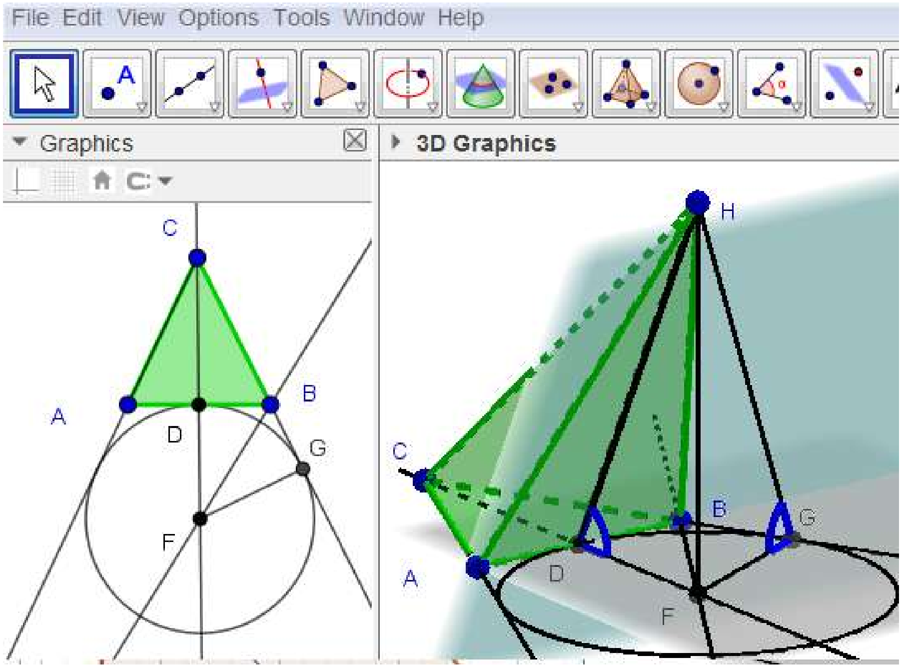

Figure 3: Image of the pyramid and linear angles.

(group 1 – 22 teachers, group 2 – 26 teachers). Some teachers among the participants of the courses did not teach students in high school that is why they do not deal with solving these very problems in their teaching.

The suggested questionnaire consisted of several questions and corresponded mainly to the Pyramid of Type 2. The participants were supposed to deal with the questions during the problem solving. Alongside the questionnaire we present the results of the survey.

1. On reading the problem situation, have you distinguished two types of the Pyramid?

A positive answer: EG – 1 student (6%), CG – no students (0%), group 1 – 5 teachers (23%), group 2 – 6 teachers (23%).

2. The participants received a clue about the way it is possible to construct the Pyramid with the obtuse dihedral angle at the base (Pyramid of type 2). The question was the following: Is it possible to construct the vertex of the pyramid projection on the plane base and in fact the Pyramid itself?

A positive answer: EG – 6 students (28%), CG – 5 students (28%), group 1 – 12 teachers (55%), group 2 – 13 teachers (50%).

3. First, a dynamic model, constructed with GeoGebra, was demonstrated to the participants. The algorithm of the Pyramid construction via the use of the tool GeoGebra Construction Steps was displayed. The task was to construct the Pyramid of Type 2 and create a problem solving algorithm individually. Next, a paper Pyramid model was demonstrated to the participants. The algorithm of the construction was discussed. The task was to construct the Pyramid of Type 2 and create a problem solving algorithm.

A positive answer: EG – 12 students (75%), CG – 8 students (44%), group 1 – 19 teachers (86%), group 2 – 17 teachers (65%). Fisher's angular transformation (Stevens, 1953) was used for the research results processing. For this purpose, the task performance proportions in the groups during the first and second stages were compared.

φ (EG, CG) = 0,61 $<$ 1,64; φ (group1, group2) = 0,31 $<$ 1,64: the received results do not differ considerably both in the groups of students and teachers.

After stage 3, the proportions of successful task performance in groups were compared one more time. φ (EG, CG) = 1,85 $>$ 1,64; φ (group1, group2) = 1,73 $>$ 1,64: the results differ significantly this time.

It has been defined that the use of dynamic models created with GeoGebra was more effective in comparison with the static paper ones.

On discussing the use of dynamic models created with GeoGebra, participants pointed out the following advantages: variability; dynamic visuals which enhance the development of spatial imagination; multiple reproducibility of the construction, which will contribute to the development of algorithmic thinking.

3.4 Tasks on Combinations of Polyhedron and Solids of Revolution

Consider the way it is possible to inscribe a sphere into the right rectangular pyramid via the use of 3D Geometry. In order to construct the base of the pyramid, it is necessary to use the Right Polygon tool, by pointing two points on the 3D canvas – adjacent vertexes of the base, and indicating that the right polygon has 4 vertexes. Then one should construct the diagonals of the square (the Segment tool) and define the center (Intersection point). Then through the center of the square, which is also the center of the circle inscribed in the square, one draws a straight line perpendicular to the plane of the square. On this straight line, one chooses an arbitrary point (Point on the object) and constructs a polyhedron (Pyramid). The perpendicular to the plane of the square straight line is the geometric location of points, equidistant from the sides of the base of the right pyramid.

To determine the position of the center inscribed sphere in the pyramid, one constructs a geometric location of points that are equidistant from the edges of the dihedral angle at the base of the pyramid. Since there is no construction of the bisector plane in the GeoGebra tools, it is necessary to construct a linear angle of the dihedral angle at the base and then bisector of the very angle. The plane passing through the vertex of the pyramid perpendicular to the edge of the base is built (Plane through the point perpendicular to the straight line; Intersection point). Instead of a plane, it is possible to draw a straight line from the vertex of the pyramid perpendicular to the edge of the base (straight, perpendicular to straight). Next, one should find the intersection point of the constructed plane / perpendicular with the edge of the base (Intersection point of the straight line and the plane / Intersection point of two straight lines). Then one builds the bisector of the obtained linear angle.

The point of its intersection with the perpendicular to the base of the pyramid, drawn from the top of the pyramid, will determine the center of the inscribed sphere (Point of intersection). Finally, one constructs the inscribed sphere (Sphere outside the center and radius), specifying in sequence the center of the sphere and the point of intersection of the diagonals of the square (Kramarenko et al., 2020).

For better understanding and mastering of the algorithm the construction of the sphere inscribed around the pyramid the students setting of the canvas are adjusted to be able to show the step-by-step procedure of the construction.

With AR, the students can understand the basic concepts of 3D geometrical shapes, their relationships and ways to construct the 3D shapes and the objects in 3D space. Importantly, AR can provide a dynamic visualization of 3D structures of geometrical shapes. This feature helps the students to understand a comprehensive background of 3D geometrical shapes and improve the abilities of geometrical structures. Moreover, the hand gesture based interactions furnish an intuitive and convenient way for the students to directly control and interact with geometrical shapes in 3D space.

GeoGebra Augmented Reality application allows you to transfer the constructed figure into the space of the room (figure 4). Having built a figure, we press the “AR” button. Next, you need to use the camera to select the environment in which we plan to move the object. For example, on the table. By tapping on the screen, the figure will be transferred to the real world (Kramarenko and Pylypenko, 2021b) where it can be explored. The phone camera will serve our eyes. Immersing the phone in a virtual figure we will see it from the inside, we can bypass it, also the application allows you to resize, color (Kramarenko and Pylypenko, 2021a).

With the experiences of interacting with the 3D shapes using their own hand gestures, the students can improve their own awareness of the relationships of the 3D shapes and easily remember or retain the knowledge about the 3D shapes.

3.5 Stereometric Problems of Applied Content

Geometry is an abstract science, often taught without proper implementation of its applied orientation. This leads to the fact that a significant part of students do not feel the need to study this subject, because they do not see the possibility of using the acquired geometric knowledge, in particular in stereometry, in the future. And so there is a need to connect stereometric problems with life. We propose to consider two problems of applied direction, for the solution of which we consider it expedient to involve the GeoGebra 3D application. We offered these tasks to students of the State University of Economics and Technologies.

Problem 1. What percentage of wood goes to waste when made of wooden logs, 5 m long and 20 cm and 15 cm in diameter, beams with a rectangular cross-section of the maximum cross-sectional area?

Problem 2. Calculate the volume of the largest beam with a base in the shape of a rectangle, which can be carved from a log of cylindrical shape. The length of the log is 5 m and the thickness is 20 cm. What percentage of wood will go to waste?

Using these tasks, we conducted research on the

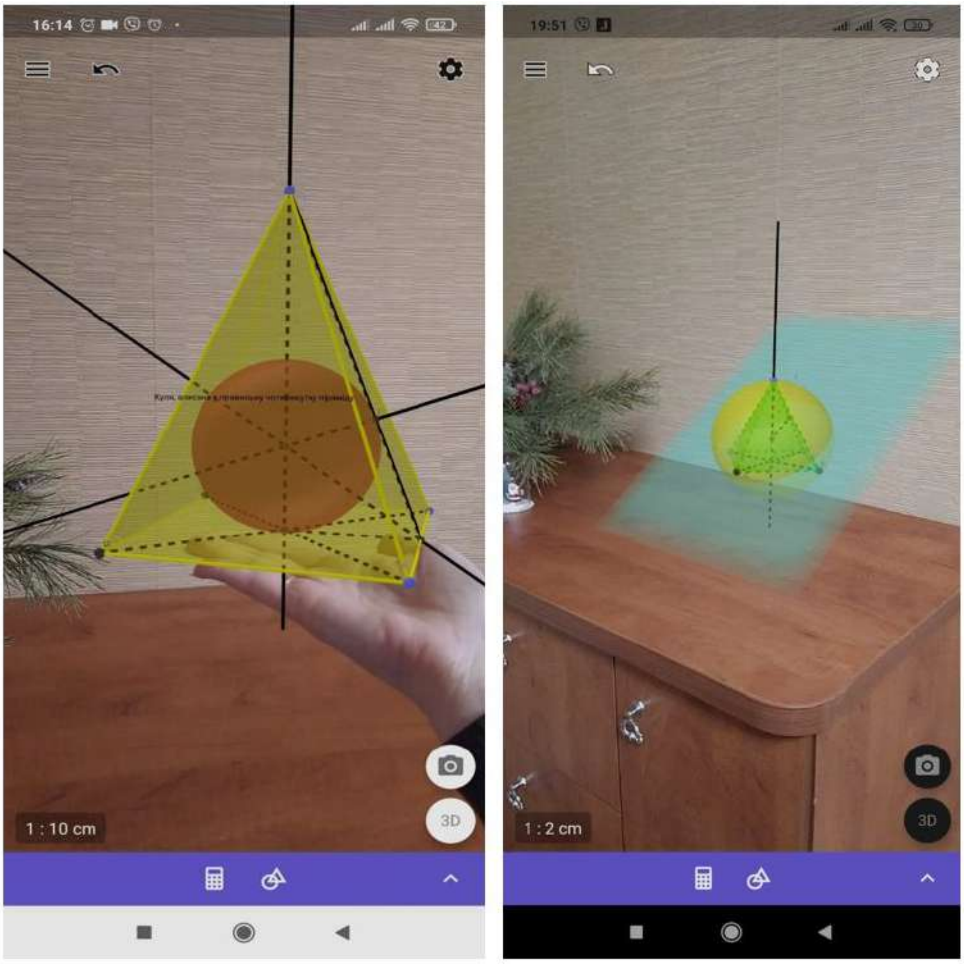

Figure 4: GeoGebra AR demos.

basis of two parallel groups majoring in “Finance and Credit”. 18 students of the experimental group (EG) and 17 students of the control group (CG) took part in the study. In the experimental group, the task was to solve problems based on a dynamic figure, the control group solved the same problems, but with the help of static.

The proposed questionnaire consisted of several questions that students answered while solving problems.

1. What figures will we work with? Positive answer: CG – 6 students (35%), EG – 7 students (39%).
2. How are the figures relative to each other? Positive answer: CG – 7 students (41%), EG – 7 students (39%).
3. What shape should be the cross section of the beam to maximize its size? The volume of the beam will be the largest if the cross section of the beam is square. It is not necessary to compose a function and study it to the extreme, it is enough to use the formula to calculate the area of a quadrilateral inscribed in a circle. Positive answer: CG – 4 students (24%), EG – 3 students (17%).

   In the second stage, the CG group was shown a figure for the problem on paper, the EG group was shown a figure in GeoGebra (figure 5) and considered in dynamics.
4. After that, the groups were asked the last question about the cross-section again, the statistics of positive answers improved: CG – 6 students (35%), EG – 9 students (50%).
5. What is meant by waste from the manufacture of logs? The positive answer that this is the difference between the volume of the truncated cone and the volume of the parallelepiped was given by: CG – 9 students (53%), EG – 12 students 67%.

The dynamic image in GeoGebra helped the EG

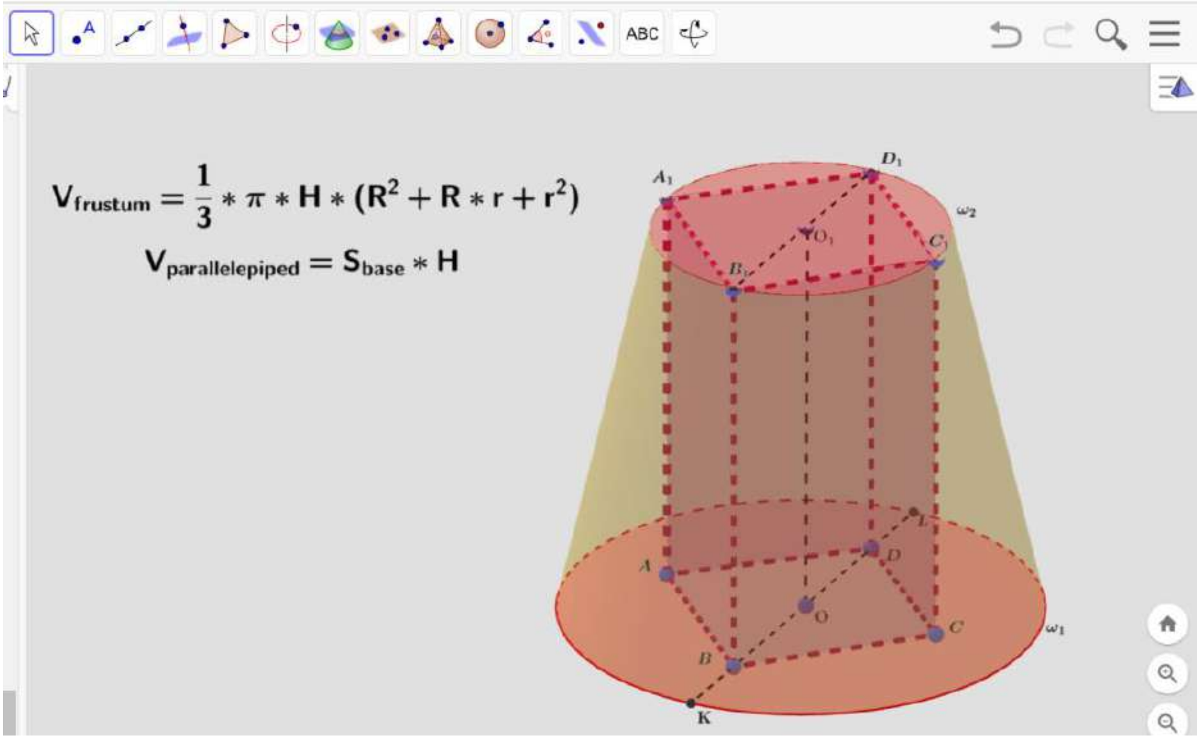

Figure 5: A parallelepiped inscribed in a truncated cone.

group to improve the statistics of responses, after the demonstration of the figure on paper this effect could not be achieved. The results of the survey showed that the highest efficiency is achieved when demonstrating dynamic models.

Optimization tasks using Geogebra were proposed by us in the textbook (Kramarenko and Pylypenko, 2021b). We supplemented the sets of tasks using Geogebra with visual aids for specialized teaching of mathematics, realization of interdisciplinary connections of the beginnings of mathematical analysis and stereometry. In this case, you can use the expressions to calculate the volume of the body to track the change in this value and find the optimal size of the beam. It is also advisable to use the “Function Inspector” tool in GeoGebra to find the extreme values of the function and visualize the abstractions.

It is convenient to write the formulas on the canvas at once, and then open them step by step during the discussion. To make such a blank in the application GeoGebra 3D, you must first build a truncated cone (by crossing the cone plane), then through the center of a smaller circle and a point on it build a line. Draw a perpendicular line to the obtained line, choosing the center of a smaller circle as a point. Mark the points of intersection of the lines with the circle and through the obtained 4 points build a square (using the Polygon tool), connecting the points in series. From the vertices of the square we lower the perpendiculars to the lower base of the cone (larger circle) and mark the points of intersection of the perpendiculars with the plane of the base of the cone, through the obtained 4 points we build a square, connecting the points in series. Using the Prism tool, build a prism by selecting a polygon of the base (square) and the vertex at one of the points of the smaller circle.

During the in-depth study of mathematics at the Kryvyi Rih Pokrovsky Lyceum, we offered students the problem of stereometry for optimization according to the textbook (Skanavi, 1990). After calculating the optimal dimensions of the prism / pyramid, the polygon scan was drawn and glued. Models in dynamics created by means of system of dynamic mathematics were offered for demonstrations. Here are examples of mathematical problems that students had to reformulate as problems of applied content.

1. (15.194) What are the dimensions of the base radius and the height of the open cylindrical tank, so that at a given volume V for its manufacture was spent the least amount of sheet metal?
2. (15.195) The side face of a regular quadrangular pyramid has a constant given area and is inclined to the plane of the base at an angle α. At what value of α is the volume of the pyramid the largest?

3. (15.196) In a regular quadrangular pyramid with the edge of the base a and the height H, a regular quadrangular prism is inscribed so that its lower base is located at the base of the pyramid, and the vertices of the upper base are placed on the side edges. Find the edge of the base and the height of the prism that has the largest side surface.
4. (15.197) The side edge of a right triangular pyramid has a constant given length and forms an angle α with the plane of the base. At what value of α will the volume of the pyramid be the largest?
5. (15.198) In a regular triangular pyramid, the side face has a constant given constant area and forms an angle α with the plane of the base. At what value of α is the distance from the center of the base of the pyramid to its side face the largest?
6. (15.199) A pyramid is inscribed in a cone with a given constant volume, which is based on an isosceles triangle with an angle at the vertex equal to α. At what value of α is the volume of the pyramid the largest?
7. (15.200) The generating cone has a constant length and forms an angle α with the height of the cone. A regular hexagonal prism with equal edges is inscribed in the cone (the base of the prism is located in the plane of the base of the cone). At what value of α is the side surface of the prism the largest?

Solving problems of applied content will provide an opportunity to motivate, intensify the educational and cognitive activities of students and promote the practical application of acquired knowledge.

3.6 Project Work in GeoGebra 3D

One of the effective means of developing students' cognitive activity is the project method. After all, the project method includes a set of research, search, problem, creative approaches, promotes the creative development of students, prepares them to solve problem situations in everyday life. Therefore, it is advisable to offer students to perform mini-projects while studying the section of stereometry.

The task of the project will be to build a playground in the GeoGebra 3D application, using the maximum number of studied geometric shapes: prisms, pyramids, spheres, cones, cylinders, etc. (figure 6). Performance appraisal is a mandatory element of the organization of project work. The effectiveness of the project lies in the ratio of planned expectations with the final results. Created designs can be designed in the yard with an augmented reality application.

There are three stages of self-regulated, namely the Planning Phase, at this stage students set steps for learning, namely (1) Analyzing learning tasks, (2) Determining learning objectives, and (3) Planning learning strategies. In the analyzing stage, students implement a plan that is constantly monitored to ensure it leads to learning goals. In the determining stage, students determine how well the learning strategy is chosen and how to achieve these learning goals (Tomaschko et al., 2018).

Students were also asked to develop a project "Artist's Room", in which students will model a room from improvised means, and before that it is advisable to offer to make a layout in GeoGebra. In this way, students will already know where to start, what sizes of objects to take, what colors will impress, what shapes are needed to create a room, they will learn to break an object into simple geometric bodies and shapes.

Project work interests students in the subject, increases mental activity and creative thinking, helps to mobilize knowledge in practice and quickly adapt to unusual situations. During the construction of a playground or an artist's room, students use innovative abilities, invention, STEM competencies are formed, such as critical thinking, creativity, organizational skills, teamwork, emotional intelligence, ability to interact effectively, cognitive flexibility.

4 CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

1. Investigating the possibilities of using GeoGebra in the learning calculus and geometry, found out that engaging students to research using GeoGebra helps to expand the range of educational tasks, including STEM problems. This allow to achieve the high level of learning motivation and individualize the learning process.
2. Implementation of applied aspect in teaching mathematics using GeoGebra 3D Calculator with AR will help to solve one of the main problems of STEM education –individualization. We can explore AR objects because this application brings 3D math to the real world. Systematic using of GeoGebra 3D Calculator with AR can help to develop students' research skills, enhance their socialization opportunities through the acquisition of ICT, which should lead to the systematic development of universal STEM competencies.

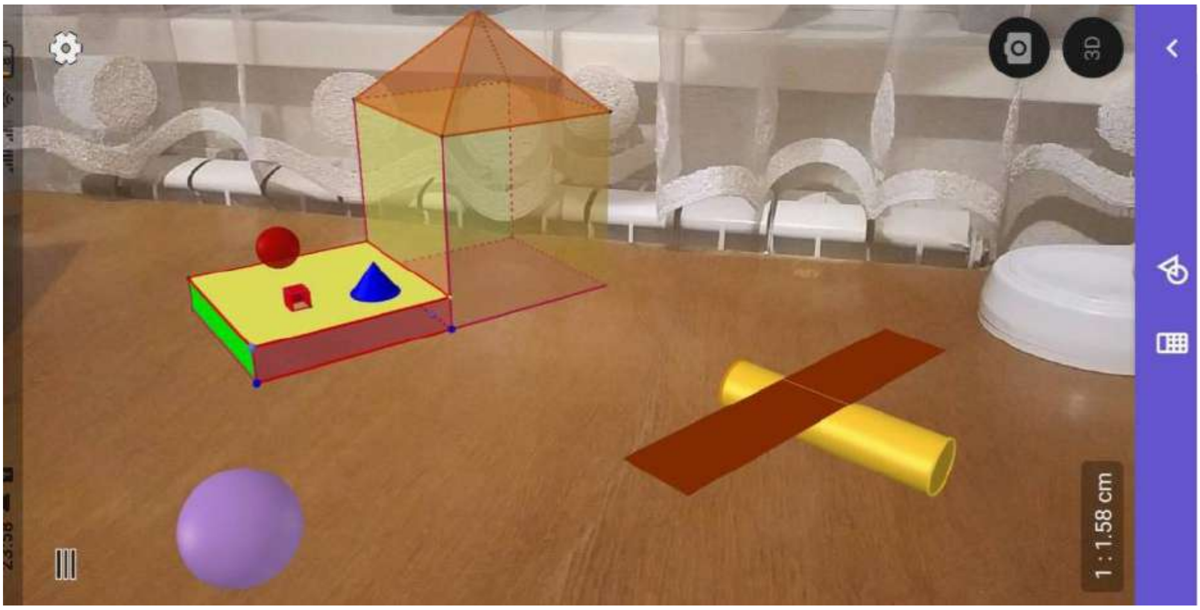

Figure 6: Sample implementation of the project “Playground”.

3. The use of dynamic geometry software GeoGebra as a modeling tool makes it possible for scientific experimental logic to engage students in discovering new mathematical facts. Teachers who are concerned by the issues of instrumented learning help to create activities which imply that the main students’ motivation is in the understanding of mathematical concepts.
4. In the process of Stereometry teaching, it necessary to divide the students into subgroups according to the type of spatial thinking. This will contribute to the implementation of the individual approach to the development of the spatial imagination, taking into account individual peculiarities, gradually complicating the task, supplementing the teaching material with visual aids, focusing on the practical application of knowledge. Actions with the models created with GeoGebra serve as an intermediate link between external actions with geometrical solid shapes and internal mental processes. Thinking must precede the external ones to engage and develop a person’s imagination.
5. In order to increase the efficiency of the perception and assimilation of stereometric material, to overcome the difficulties in transcoding the symbols of a spatial body and to create an adequate spatial image, it is necessary to supplement the theoretical material with multimedia demonstration models created by the means of ICT, to encourage students and to engage them in the process of creating such models for classes independently. After all, the acquisition of mathematical competence depends not on memory, but on the activity in which the person is involved, on the system of mental operations that they perform in the process of knowledge acquisition.
6. In general, the result of the research study is the improvement of teaching methods of Mathematics via the use of cloud technologies, the implementation in the educational process of methodological materials of pedagogically balanced and appropriate blending of traditional and innovative learning tools, which contribute to the intensification of teachers’ readiness for the use of STEM training in teaching.

In the future, it is necessary to explore the conditions for the effective use of other GeoGebra mobile applications in STEM learning.

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An Experiment on the Implementation the Methodology of Teaching Cloud Technologies to Future Computer Science Teachers

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Abstract: The article deals with the problem of training future computer science teachers for the use of cloud technologies. The authors analyzed courses from leading universities to study cloud technologies. On this basis the model of application and studying of cloud technologies in the process of training of future teachers of informatics was developed. The basic principles of this model are proposed: systematic, gradual, continuous. It contains target, content, operating and effective component. Therefore, the stages of using cloud computing technology were proposed: as a means of organizing learning activities, as an object of study, as a means of development. The article summarizes the experience of designing a cloud-based learning environment (CBLE). The model is based on such philosophical and pedagogical approaches as systemic, competent, activity, personality-oriented, synergistic. Hybrid cloud is the most appropriate model for this environment. It combines public and private cloud platforms. CBLE also requires the integration of cloud and traditional learning tools. The authors described the most appropriate teaching methods for cloud technologies such as classroom learning, interactive and e-learning, practical methods. The article contains many examples of how to apply the pro-posed methodology in a real learning process. The evaluation of the effectiveness of the author's methodology was carried out by using diagnostic tools such as analysis of questionnaires, tests, laboratory and competency tasks. The paper contains a justification and description of the pedagogical experiment. The authors performed a quantitative analysis of its results and verified their reliability using the methods of mathematical statistics.

1 THE PROBLEM STATEMENT

Today, the trend of ICT development is the digitization of all sectors of public life. As a consequence, there is an intensive integration of information and communication technologies (ICT) into the learning process. Nowadays, teachers are often used cloud computing in training process. This remote computing model provides greater accessibility and openness to education (Bykov and Shyshkina, 2018). Cloud computing enables students to work with educational materials regardless of their hardware, software and geographical location. Therefore, the study and use of these technologies is mandatory in the curricula of colleges and universities. This problem becomes especially relevant in the case of preparing bachelors of computer science and teachers of informatics.

The purpose of the article is to design content and study methods for cloud computing in the process of training future computer science teachers.

The following tasks are required to achieve the goal of the research:

1. To analyze the state of education in cloud technologies at leading foreign and Ukrainian universities.
2. To define the concept and principles of teaching cloud technologies to future computer science teachers.

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3. To offer content and training methods for cloud technologies.
4. To conduct an experimental verifying of suggested methodology.

The object of the study is the computer science teachers training process.

The subject of the study is a model of study cloud technology by future computer science teachers.

We used a set of research methods: theoretical – analysis of scientific, technical literature, experience; generalization of experience of using cloud computing in education, empirical: observation, analysis, modeling method, methods of mathematical statistics.

2 ANALYSIS OF CLOUD COMPUTING LEARNING EXPERIENCE

Cloud technology training is on the list of courses from leading US and European universities. Some of them are focused on the study of individual cloud platforms, while others involve the study of the theoretical foundations of cloud technologies. One major subject is administration training, while other students are learning to develop cloud applications.

For example, at Harvard University, students are offered a course in Fundamentals of Cloud Computing with Microsoft Azure. The content of this course covers the fundamental architecture and design patterns necessary to build highly available and scalable solutions using key Microsoft Azure platform as a service (PaaS) and server less offerings. The students learn fundamentals necessary to make a system ready for users, including always-up architecture and deployment strategies, rollback strategies, testing in production, monitoring, alerting, performance tuning, snapshot debugging in production, and system health analysis using application insights and analysis services (Harvard University, 2020).

Berkeley University offers a Cloud Computing: Systems course. In this course, teachers describe the technology trends that are enabling cloud computing, the architecture and the design of existing deployments, the services and the applications they offer, and the challenges that needs to be addressed to help cloud computing to reach its full potential. The format of this course will be a mix of lectures, seminar-style discussions, and student presentations. Students will be responsible for paper readings, and completing a hands-on project (CS294, 2011).

Cambridge University invites students to study cloud computing. This course aims to teach students the fundamentals of cloud computing covering topics such as virtualization, data centres, cloud resource management, cloud storage and popular cloud applications including batch and data stream processing. Emphasis is given on the different backend technologies to build and run efficient clouds and the way clouds are used by applications to realize computing on demand. The course includes practical tutorials on different cloud infrastructure technologies. Students assessed via a Cloud based coursework project (Kalyvianak and Madhavapeddy, 2019).

At the University of Helsinki, students take the Cloud Computing Fundamentals: AWS course. Students learn how to use Amazon Web Services as a cloud computing platform. This course covers topics required for AWS Developer Associate certification. The course involves the creation and use of a trial account on AWS (University of Helsinki, 2019).

Yale University offers a Cloud Networking and Computing course. In this course, students will visit the critical technology trends and new challenges in cloud and data center designs for different trade-offs of performance, scalability, manageability, and cost in the networking layers and big data analytical frameworks. This course includes lectures and system programming projects (Yu, 2017).

Another approach is to study cloud technology in research labs and training centers. At MIT there is a laboratory called “Parallel & Distributed Operating Systems Group”. Teachers and students have conduct research in cloud systems, multi-core scalability, security, networking, mobile computing, language and compiler design, and systems architecture, taking a pragmatic approach: they build high-performance, reliable, and working systems (pdos.csail.mit.edu, 2019).

The California State Polytechnic University is implementing a project to create a data center training facility through a partnership between the university and leading cloud platform developers (Microsoft, Avanade, Chef, Juniper). The Center is engaged in the deployment of a corporate cloud, through which practitioners will teach students the design, configuration, implementation and maintenance of cloud services and platforms (Hwang et al., 2016).

Another promising way to acquire ICT competencies is to study with massive open online courses (MOOCs) (Zinovieva et al., 2021). Students have the opportunity to acquire knowledge independently when they study in them. Universities can also integrate these courses into their own subject disciplines. Leading online platforms offer many cloud technology training courses.

For example, there is an Introduction to Cloud

Infrastructure Technologies course on the EdX platform. It contains many chapters. These include basic: Virtualization, Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Containers and the latest such as Tools for Cloud Infrastructure, Internet of Things, How to Be Successful in the Cloud (LinuxFoundationX, 2019).

Coursera offers several courses to study: Essential Cloud Infrastructure: Foundation, Essential Cloud Infrastructure: Core Services, Elastic Cloud Infrastructure: Scaling and Automation, Google Cloud Platform Fundamentals: Core Infrastructure. These courses explore the Google Cloud Platform and AWS platforms (Coursera, 2019). In addition to high-quality educational content, the Courser platform provides access to the Google Cloud Platform and Amazon Web Services with the QuickLabs service. There, students can not only perform laboratory tasks, but also check the quality of their performance.

Udacity has developed a Become a Cloud Dev Ops Engineer nanodegree program. It provides learn to design and deploy infrastructure as code, build and monitor pipelines for different deployment strategies, and deploy scalable microservices using Kubernetes. At the end of the program, students will combine new skills by completing a capstone project (Udacity, 2019).

The Computing Curricula 2017 document that is used in the development of IT education standards in the IT domain ITS-CCO (Cloud Computing) involves the study of such chapters (Task Group on Information Technology Curricula, 2017):

ITS-CCO-01 Perspectives and impact;

ITS-CCO-02 Concepts and fundamentals;

ITS-CCO-03 Security and data considerations;

ITS-CCO-04 Using cloud computing applications;

ITS-CCO-05 Architecture;

ITS-CCO-06 Development in the cloud;

ITS-CCO-07 Cloud infrastructure and data.

Researchers and teachers from Ukrainian universities are also developing cloud computing courses. For example, the standards of the specialty "123 Computer Engineering" defined the ability of a specialist to analyze and design high-performance computer systems with different structural organization using the principles of parallel and distributed information processing (tntu.edu.ua, 2018). The course "Cloud Technologies and Services" was developed in National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". This course covers the following topics: Cloud technologies and services, Cloud security, Service Models, Google App Engine for Java platform, RESTful API build in Java. The Cloud Technologies course is taught at the Shevchenko National University's Faculty of Information Technologies. The course covers basic information about the emergence, development and use of cloud computing technologies. Typologies of cloud deployment (private, public, hybrid, public, etc.), cloud computing service models (SaaS, PaaS, IaaS, etc.) are considered. The discipline provides an overview of the modern solutions of the leaders of the cloud computing market – Amazon, Microsoft and Google. The advantages and disadvantages of cloud computing models and their solutions are considered. To develop practical skills in the discipline, it is proposed to deploy transactional web applications in cloud environments, transfer ready-made solutions to them, learn how to administer them, and work with virtualization technologies (http://matmod.fmi.org.ua, 2019).

3 DESIGNING A CLOUD COMPUTING TRAINING MODEL

Teaching future IT teachers the use of cloud technologies is also relevant. Usually, the pedagogical universities of Ukraine study courses focused on the use of cloud technologies in education. Most of them focus on the study of public clouds of Google Suite or Microsoft Office 365 (pnpu.edu.ua, 2019; fit.univ.kiev.ua, 2016).

In general, Ukrainian and European universities use cloud platforms to create their own cloud-based learning environment (CBLE). A methodology for using cloud computing for train informatics teachers and postgraduate students was developed in (Bilousova et al., 2018; Bykov and Shyshkina, 2018; Markova et al., 2018).

We interpret the concept of "the use of cloud technology" as an introduction to the practical work of a computer science teacher. Appropriate training of bachelors of computer science should be carried out continuously and in stages throughout the study period. Its effectiveness depends on the level of use of the tools in the learning process. Therefore, it is necessary to develop a model of organization of students' learning based on cloud technologies. As a result of the introduction of the proposed model, students develop ICT competencies for using distributed cloud resources for training and research.

The cloud-based student learning organization model changes the traditional reproductive approach to practically oriented learning. For its design we have analyzed similar models. They usually contain motivational, cognitive, activity, productive components (Selviandro and Hasibuan, 2013; Paduri et al., 2013).

They all transform the educational process from a system that operates on externally set standards to a self-evolving system. The main components of our model are shown in figure 1.

The target component of model provides the creation of conditions for the organization and support of joint educational and research work of students. It provides for the formation of cloud based learning environment of a university. Based on the previous analysis, we can claim that there is a social demand for a teacher who has competencies in the use of cloud technologies. Such a teacher should be able to organize the CLBE of school, to form the appropriate competence in students. In each of these three stages, we envision students using cloud computing at a different level of awareness. The purpose of this component is the goal setting of stage, on which the effectiveness of the whole process depends. The target component also determines the creation of conditions for the formation of personal capacity for future professional activity in the conditions of modern technological changes.

The purpose of training is implemented through methodological approaches such as:

- the competency approach allows to identify the content of ICT competencies in the use of cloud technologies, to improve the practical orientation of the learning process;
- the system approach allows to consider all components of the proposed model as a coherent system. A system approach requires designing the model as a set of interrelated elements. Integrative dependencies and interactions of these elements are also needed;
- the action approach focuses on the prioritization of active learning methods;
- synergistic approach considers the basic processes of student self-organization and interaction. Learning according to this approach is an unstable process. This instability complicates adaptation, cognitive operations, and overall activity.

The guiding principles of the methodology according to our model are the traditional principles of science, accessibility, continuity, systematicity and consistency, activity, clarity. Other principles of learning such as mobility, adaptability, flexibility, ubiquity are also important.

The content component of the model is aimed at developing both the key (digital, personal, social, educational) and subject competences of future computer science teachers.

At the center of the proposed model is a student. Accordingly, the competence structure defines the components by the stages of implementation. They correspond to the preparatory, activity, generalization stages of the use of cloud technologies. The study in the preparatory and activity stage should be done in the bachelor's degree. The generalization stage can be implemented as a master's program.

At the preparatory stage, cloud technology is a means of organizing educational and cognitive activity. The relevant components of subject competence are such as:

- ability to be guided by features of modern cloud technologies, to understand their functionality and to be used for basic educational tasks;
- ability to distinguish between features and characteristics of "traditional" Internet services, hosting web resources, running virtual private machines in cloud infra-structures;
- ability to determine the ways of using cloud technologies for the organization of training and research activities according to service models;
- ability to behave adequately and responsibly in a cloud environment, to demon-strate knowledge and understanding of the legal, ethical aspects of using cloud services and digital content;
- ability to actively and constantly explore new services, implement them in their activities, awareness of the role of cloud computing in the current stage of IT and education.

In the activity stage, cloud computing is the object of study. The relevant components of subject competence are such as:

- knowledge of basic concepts, deployment models and service models of cloud technologies, principles of operation and technology of server system virtualization, architecture and standards of distributed computing, and features of hard-ware and software solutions of modern data centers;
- ability to install, configure and maintain system, tool and application software of cloud platforms according to the basic service models;
- ability to evaluate and determine effective CBLE deployment decisions based on an analysis of the functional characteristics of cloud services and the needs of educational institutions;

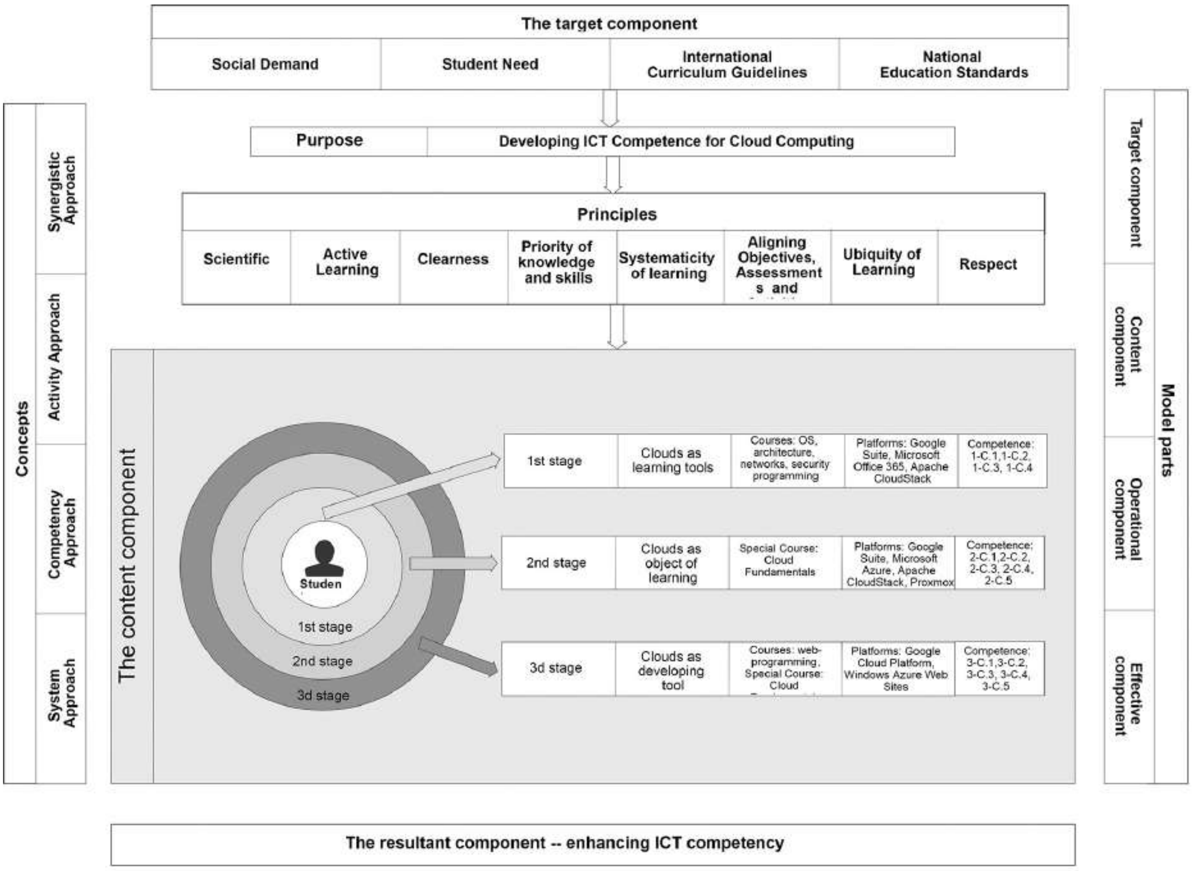

Figure 1: The model for learning cloud computing.

- ability to design, deploy and integrate ready-made cloud platforms to improve the IT structure of the educational institution;
- ability to monitor, support and analyze the functioning of the CBLE.

At the generalization stage, cloud computing is a development tool for creating educational resources and learning tools. The relevant components of subject competence are as follows:

- ability to formulate requirements for quality assurance of software development for its functioning in the cloud applications;
- ability to evaluate and identify effective deployment solutions for CBLE based on a comparison of the technical and economic properties of cloud computing services, as well as for solutions based on private and hybrid cloud systems;
- ability to formulate ways to increase the efficiency of the use of cloud technologies in solving organizational educational and scientific tasks;
- ability to develop software for educational institutions in a cloud computing environment, test and debug relevant hardware and software;
- ability to project activities, work in a team to jointly solve educational and scientific tasks.

The technological component of the model defines the system of teaching methods. We consider appropriate methods of teaching cloud technologies such as:

- classrooms training (lectures, storytelling, presentations, group discussions, tutorials etc);
- interactive methods (quizzes, small group discussions, case studies, participant control, demonstrations etc);
- services, as well as for solutions based on private and hybrid cloud systems;
- e-learning (web-based training, web meetings, webinars, collaborative document preparation, work in CBLE);
- practical training methods (project, training).

In general, these methods aim at providing a blended learning methodology. Their application is possible during lectures, laboratory work, self-study trainings, individual and group consultations. We include the traditional means and components of CBLE in the training tools.

To provide group work and student feedback in each course, we use tools such as:

- emails and messengers;
- software for remote access to the objects of students in CBLE;
- module and final tests;
- Likert scale course feedback.

The resultant component of the model involves providing ubiquitous access to learning resources through standardized protocols, enhancing students' ICT competency, improving the quality of educational process organization and pedagogical research.

We consider it necessary to use public and private clouds as a teaching tool not only in the first stage, but also throughout the whole time of studying the bachelor of computer science. Such public clouds are G Suite and Microsoft Office 365. Their developers offer free subscriptions to educational institutions. Students and staff can get corporate accounts of these cloud platforms. The use of these platforms can be practiced in almost all courses of professional training of the future computer science teacher.

For example, a teacher can schedule study assignments, student work, online consultations using Calendar services. For training demonstrations, webinars can be effective cloud services such as Google Meet and Skype for Business and more.

Topical issues of using cloud technologies in training are their integration with each other and with other learning tools. Such integration should provide single authentication (Single Sign-On – SSO), content availability in various cloud services, access from mobile devices, and ability to monitor student activity.

Great technical and training capabilities are in the deployment of private academic cloud according to the IaaS model. We have deployed a similar cloud based on the Apache CloudStack platform. It combines the system resources of 4 servers. This allows you to run 20-50 virtual machines at a time. With Apache CloudStack's enhanced networking capabilities, we have integrated these computers into a large number of virtual local area networks (VLANs). To provide universal access to the virtual labs, 2 virtual private network (VPN) servers were set up. They work with different protocols. Therefore, students are able to work with these labs from any device that has Internet access. All these services have formed a cloud infrastructure that is integrated into the university's LAN. Such an academic cloud makes it possible to create "cloud laboratories". In our opinion, a cloud lab is a system where virtual ICT objects are generated through cloud computing and networking. Cloud labs are best used to teach basic computer science courses, such as computer architecture, operating systems, programming, computer networks, and more.

One of these laboratories (CL-OS) was deployed for training. Its purpose was the development of ICT competences, the education of the need for systematic updating of knowledge, the formation of project activity skills. To complete with the tasks, the students were supposed to have basic knowledge of the following disciplines: Operating Systems, Computer Architecture and Software. The main teaching methods in this training were group and project techniques. Students' educational projects were about practically important tasks, such as: recovery of destroyed data, increase of operating systems performance, error correction during loading, virus removal.

Students use G Suite and Microsoft Office 365 public clouds to discuss learning problems, create and edit shared documents (diagram, abstract, brochure, booklet, infographics). They acquire teamwork skills such as communication, teamwork and group leadership; formulation of tasks for yourself and colleagues, perform tasks in a timely manner (Spirin et al., 2018).

Each of the group members was provided with a separate virtual machine. It had defects of one of the above types. Students were able to work on solving problems not only from any university computer, but also from their home PC. To train one group of students, an academic cloud provided 20–30 virtual machines (VMs).

Another cloud lab (CL-EVE-NET) was organized to study computer networks. We have integrated the Apache CloudStack and EVE-NG Community Edition platforms to deploy it. Nested Virtualization technology was used for this purpose. The EVE-NG platform makes it possible to emulate the operation of different nodes that are integrated in an internetwork. These nodes can be virtual machines running different operating systems. The integration of EVE-NG and Apache CloudStack platforms enables the use of full-featured network OS.

The integration of EVE-NG and Apache CloudStack platforms enables the use of full-featured network OS. They can be accessed via the EVE-NG platform web interface and through Telnet and VNC protocols. This lab uses both Apache CloudStack virtual networks and ENE-NG platforms. If the student configures the network connections correctly, access will also be available through the appropriate protocols.

We used the CL-EVE-NET lab to study basic computer network topics, such as: switching and bridging, network monitoring tools, basic and NAT routing; dynamic routing protocols; load-balancing Internet channel, policy base routing, data filter with firewall, network protocols and services (DHCP, ARP, DNS); virtual private network protocols (Spirin et al., 2019).

This cloud lab allows you to bring together individual student networks. As a result, we get a internetwork of group. This approach ensures student collaboration and teamwork. An error with one of them can causes problems throughout the network. For the training of one group of students, an academic cloud provided the functioning of 20 "parent" VMs. They ran up to 10 nested virtual network devices (bridges, switches, routers, hosts).

The CL-ADM cloud lab has been deployed for the network administration course. In this course, we use both Windows and Linux. So, to study each topic, we create at least 2 virtual machines as servers and at least 2 VMs as clients.

The main topics of the course are:

- network administration of Windows and Linux servers (local users and groups, filesystems security, network shares, remote administration);
- domain administration (Active Directory, Samba, NIS);
- server application administration (Apache, ProFTPd, IIS, Postfix, Dovecot SQUID).

To train one group of students, an academic cloud provided 30–40 virtual machines. Training at the activity and generalization stages is carried out according to the special program "Cloud Technologies Fundamentals".

The course involves the study of: publicly available cloud platforms by recognized software development vendors (Google Inc., Microsoft), and open source software as the foundation for enterprise cloud.

The main topics of the special course are:

- public cloud platforms (G Suite and Microsoft Office 365);
- cloud platforms for private clouds (Apache CloudStack, Proxmox).

We used to study the G Suite and Microsoft Office 365 public platforms in the form of a Cloud Services to Every School project (Oleksiuk et al., 2017). The objectives of the project were to design and deploy cloud services for secondary schools. The basics of the project concept were: absence of material costs for deployment and support of cloud services, voluntary nature of participation in the project. In collaboration with computer science teachers, students determined which services needed to be configured or migrated to the cloud. The problems of maintenance and support required a lot of time. Teachers had questions about administering, configuring, monitoring cloud services. We solved such problems by organizing face-to-face and distance seminars, workshops, also through the involvement of students in the support of deployed systems.

The results of the "Cloud Services to Every School" project is in line with the indicators of a cloud-based learning environment. They are: quality and accessibility of learning, adaptability, interactivity and mobility of ICT tools, unification of the school's IT infrastructure, ensuring its security.

We propose to study private clouds on the example of open platforms. We suggest exploring private clouds as an example of open platforms. Their advantages are open source, freeware, English documentation, the ability to deploy advanced cloud infrastructures. However, such platforms are usually not supported by the developer. Therefore, teaching students with such platforms often requires them to look for solutions to various problems. This approach requires modern hardware. Private clouds require servers that perform different functions. For deployment by students of such clouds it is necessary to use the group method. It is a division of tasks. Students can perform tasks together or individually such as:

- configuring the database server;
- cloud platform setup;
- installing hypervisors;
- creating virtual computers;
- distribution of system resources.

In the future, students change roles. Since at our university the special course "Fundamentals of Cloud Technologies" is studied in the master's program, we consider it appropriate to use a research approach. It is that the teacher formulates detailed technical requirements for the cloud. Students research and customize platforms to meet these requirements. The results of such research can be summarized by the method of comparative analysis. For example, one platform may have better performance for the production platform and another platform will perform more effectively as part of the CBLE.

Important in the ICT competency of the future computer science teacher is the possession of software development tools. Cloud services should be at the forefront of creating students' own educational information resources. The third stage of our model is dedicated to this task.Training can be based on this platform leader in software and cloud.

Microsoft has developed a Windows Azure Web Sites product that enables students to create new and host existing web applications in a secure cloud storage. Windows Azure Web Sites implements a Platform as a Service (PaaS) model. Therefore, students will be able to fully focus on the programming and direct development of their cloud projects.

Google also offers a similar Google Cloud Platform (GLP) cloud service. It allows you to create, test and deploy your own applications in the cloud. Students can learn how to create state-of-the-art web applications and mobile applications on the open Google App Engine cloud platform. It is a managed platform that completely abstracts the cloud infrastructure, which helps to focus training on development tasks.

Deployment of cloud laboratories is also appropriate for a full study of these systems. Unfortunately, Google has not yet provided academic grants to use GLP for Ukrainian universities. However, students are free to use their own accounts for one year. A similar situation with Microsoft products. It is necessary to get a Microsoft Azure Education Grant for effective learning.

We propose to use a comprehensive approach and project methodology in the process of studying these tools. The main requirements of applying the project methodology at this stage are as follows:

- identifying the main problem that the created project should solve;
- requirement for student creativity in project development;
- no restrictions on the tools and their functionality;
- the value of the expected result, that is, a cloud-based application must be developed and deployed;
- organization of joint activities of students;
- identification of pre-formed competencies for project creation;
- the project's focus on modern cloud and web technologies.

The third (generalization) stage of our methodology consists of several logical parts. They combine a relatively small amount of theoretical material. It's a good idea for a teacher to start learning about the Google Cloud Platform (GCP). The practical part involves setting up the environment and creating a project, configuring a cloud database. The next task is to log in and log in. After that, students should focus on project architecture and development of core functionality.

We invite students to develop a contact manager. Its main functionality is to enable an authorized user to create, view, edit and delete records. It also has the option of sending e-mails to selected contacts. This basic functionality is present in almost every modern web application. Students can use GCP cloud products such as Google App Engine standard environment, Google Cloud SQL, Google Cloud Datastore, Google Cloud Storage and Google Cloud Pub to develop it.

Application development in the Google Cloud Platform facilitates group form organization. The teacher can add new project participants and assign them specific roles to determine the degree of access. In this project, the teacher demonstrates GLP capabilities based on such programming tools as PHP and Node.js. Important issues for cloud-based application development are understanding:

- basic functionality of PHP and Node.js;
- basics of a modular, file and batch system;
- file management;
- use of the postal service;
- work with the MySQL database.

The next step is to introduce students to the Google Cloud Platform environment, the basics of App Engine, and the application deployment process. It is a good idea for the teacher to organize the development of the project in a private university cloud and then deploy it into a public cloud. It is also possible to develop the project only in a cloud environment. Both approaches include steps to develop a web application that will allow users to submit requests to the server.

After completing these tasks, students develop their own ICT competencies such as:

- creating a GCP project based on App Engine;
- writing a web server on Node.js;
- deploy code on App Engine and view the web application in real time;
- adding updates to an already deployed service.

After creating this application, students move on to expand its functionality through other GLP services. Further practical work focuses on developing students' own cloud applications. These can be an online study log, e-library, video hosting service, photo gallery etc. Their students perform in small groups of 2-3 people. They can offer their own themes for development. Upon completion, students present projects and share their experiences and achievements.

4 TESTING THE EFFECTIVENESS OF THE AUTHOR'S METHODOLOGY

We conducted a pedagogical experiment to verify the developed methodology. The study was conducted during 2016–2020. We investigated the development of ICT competence under the conditions of implementation of the proposed model. The aim of the study was to identify changes in the levels of ICT competence of students. According to Mazorchuk et al. (Mazorchuk et al., 2020) this competence contains basic theoretical knowledge, methods of practical activity, motivational relations and the ability to apply cloud technologies in the future. They almost completely correspond to the structure of our model of application of cloud technologies. Let's look at each of these components.

The motivational (target) component contains motives, goals, needs for professional training, self-improvement, self-development by means of cloud technologies. It stimulates creativity in the professional activities of a computer science teacher. Accordingly, the student must develop a need for constant updating of his (her) own knowledge. The motivational component contains the motives for teaching, the focus on the development of students' personalities.

The content component of ICT competence of future computer science teachers provides free mastery of skills in working with digital objects. The level of development of the content component is determined by the completeness, depth, system of knowledge of computer and related sciences. It requires knowledge of the principles of cloud computing, its use for the design and development of educational resources. Knowledge of the security threats and limitations of these tools is also required.

Activity (operational) component involves the development of skills (including soft-skills) for the application of cloud technologies in future professional activities. These include the ability to establish interpersonal relationships in the educational environment, to choose the right style of communication in different situations. Basically, this component requires the skills and experience needed by future computer science teachers to solve problems using cloud technology. Advanced development of this component requires mastering and forming the readiness of future computer science teachers to develop and implement cloud computing in the educational process. The formation of appropriate skills should be determined by the professional needs of future computer science teachers.

The reflective (effective) component of ICT competence is determined by the attitude of students to their practical activities. It includes self-control, self-esteem, understanding of their own role in the team. Important for this component are the evaluation of the results of their activities, understanding the responsibility for its results, professional self-realization through the means of cloud technologies.

The study was conducted during 2016–2020. It had ascertaining and search stages. The ascertaining stage corresponded to the first and second stages of the author's model. The study was conducted in the bachelor's course "Computer Networks". Since most of the components of the author's model are implemented at the generalization stage, we decided that the search stage should be performed in the process of learning a special course " Cloud Technologies Fundamentals".

At each stage of the experiment, the following data were processed:

- results of the questionnaire like course feedback, as data for studying the target component;
- grades for all course tests as data of the content component of the model;
- grades received by students for laboratory work as data of the operational component;
- assessments for a competency task as data of the effective component.

For statistical processing of these data, we used the methodology developed by Olena Kuzminska (Kuzminska, 2020). To ensure a sufficient sample size, we had to process the data for 4 years. We studied the changes and tried to identify differences in the data of each of the components of ICT competence. To ensure the homogeneity of the groups at both stages, the results of questionnaires and assessments of the same students were processed. There were a total of 196 students in these study periods. All data of the ascertainment and search stage are available by the following link https://drive.google.com/file/d/1n-lPQI-eGFMJiuwq_jI7BaWoM3aTUNK0.

Assessment in each of the courses was on a 100-point scale with a distribution such as:

- maximum 40 points for the test tasks of the course (content component);
- maximum 40 points for laboratory work (operational component);
- maximum 20 points for the performance of the competence task (effective component).

In addition to 20 points, the student could receive for answering the questionnaire, which gave an answer to the feedback about the course. To choose a statistical method, we took into account the following facts:

1. The data are quantitative; therefore, we can use numerical scales.
2. The data may not correspond to the normal distribution. Therefore, it is necessary to check this for each of the components of ICT competence at each stage of the study.
3. Samples of each year of study are independent.
4. There are 4 groups for comparison.

We performed data processing using the R language. First, we checked the data distribution of each component is normal for the ascertaining stage.

```
lillie.test(AscertainingStageData$Target)
#Lilliefors (Kolmogorov-Smirnov) normality
# test
#data:  AscertainingStageData$Target
#D = 0.074284, p-value = 0.01045
lillie.test(AscertainingStageData$Content)
#Lilliefors (Kolmogorov-Smirnov) normality
# test
#data:  AscertainingStageData$Content
#D = 0.056802, p-value = 0.1276
lillie.test(AscertainingStageData$Operational)
#Lilliefors (Kolmogorov-Smirnov) normality
# test
#data:  AscertainingStageData$Operational
#D = 0.055232, p-value = 0.1531
lillie.test(AscertainingStageData$Effective)
#Lilliefors (Kolmogorov-Smirnov) normality
# test
#data:  AscertainingStageData$Effective
#D = 0.085305, p-value = 0.001434
```

As can be seen from the code listing above, the data distributions of the content and the operational components are normal, and the target and effective are not. Therefore, a more powerful one-way ANOVA method for independent groups can be used to process the first two cases. Another pair of components should be processed using a non-parametric Kruskal–Wallis one-way analysis of variance. These methods allow to check whether the studied groups are homogeneous.

Additionally, for the ANOVA method, the homogeneity of variances in each distribution should be checked. We performed this using Levenés test for homogeneity.

```
leveneTest(AscertainingStageData$Content\
~AscertainingStageData$Years,
AscertainingStageData,center=mean)
#Levene's Test for Homogeneity of Variance
# (center = mean)
#       Df F value Pr(>F)
#group   3  0.2084 0.8905
#       192
leveneTest(AscertainingStageData$Operational\
~AscertainingStageData$Years,
AscertainingStageData,center=mean)
#Levene's Test for Homogeneity of Variance
# (center = mean)
#       Df F value Pr(>F)
#group   3  1.6235 0.1853
#       192
```

As can be seen from the listing F value = 0.8905 and F value = 1.6235 (for content and operational components in accordance). These values are smaller for the critical value $F_{0.05}(3; 192) = 8.53$. The corresponding p-values (Pr = 0.8905 and Pr = 0.1853) are greater than the significance level ($\alpha = 0.05$). This is a reason to reject the null hypothesis about the difference of variances in the samples. Therefore, the ANOVA method can be used for the content and activity components.

Then the null and alternative hypotheses are as follows:

- H0 – there are differences between the groups at the ascertaining stage;
- H1 – there are no differences between the groups at the ascertaining stage;

The following code contains a test of these hypotheses.

```
summary(aov(Content~Years,
  data=AscertainingStageData))
#           Df Sum Sq Mean Sq F value Pr(>F)
#Years       3     57   18.96   0.822  0.483
#Residuals 192   4431   23.08
summary(aov(Operational~Years,
  data=AscertainingStageData))
#           Df Sum Sq Mean Sq F value Pr(>F)
#Years       3     57   19.04   0.751  0.523
#Residuals 192   4870   25.36
```

Thus, for both components we can reject the zero and accept the alternative hypothesis. Similar hypotheses can be formulated for the target and effective components. Here is a test of group homogeneity for these components using the Kruskal-Wallis one-way analysis of variance.

```
kruskal.test(Target~Years,
  data = AscertainingStageData)
#Kruskal-Wallis rank sum test
#data:  Target by Years
#Kruskal-Wallis chi-squared = 6.3968,
# df = 3, p-value = 0.09382
kruskal.test(Effective~Years,
 data = AscertainingStageData)
#Kruskal-Wallis rank sum test
#data:  Target by Effective
#Kruskal-Wallis chi-squared = 0.55391,
# df = 3, p-value = 0.9069
```

The test showed that we can accept an alternative hypothesis about the homogeneity of groups. The task of the search phase of the study was to identify differences between groups during the 2017-2020 years of the study. During this period, in each academic year, we introduced the some technical and methodological components of the mod-el such as:

- 2016–2017: deployed CL-OS laboratory;
- 2017–2018: the project "Cloud services in each school" was implemented;
- 2018–2019: deployed CL-EVE-NET and CL-ADM laboratories;
- 2019–2020: Coursera courses on Google Cloud Platform are included in the special course "Cloud Technologies Fundamentals".

Similar to the ascertainment stage, we analysed the results of the questionnaire, grades for tests, laboratory works and competence task.

The questionnaire for diagnosing the level of the motivational component contained 20 questions. For each positive answer to the questionnaire, the student received one point. Points for completing the questionnaire, grades from the course were obtained by students in a special course " Cloud Technology Fundamentals " in 2016-2020. Here are the questions.

1. I understand the importance of cloud technologies for the organization of educational activities.
2. I understand the importance of cloud technologies for the organization of design and research activities of students.
3. I understand the importance of cloud technologies for the organization of extracurricular activities of students.
4. I am aware that cloud technologies expand the opportunities for the development of students' ICT competence
5. I follow the emergence of new cloud services for education.
6. I am watching the emergence of new platforms for the deployment of private clouds.
7. I have studied cloud platforms in MOOCs.
8. I have the skills to develop cloud applications.
9. I can develop separate cloud services for CBLE school.
10. I know the benefits of cloud services as a means of supporting teacher self-development and self-improvement.
11. I understand that the use of cloud services has a positive impact on the quality of teaching and diversifies forms of learning.
12. I try to monitor the emergence of new resources and tools for cloud technology to improve their competence.
13. I realize that it is necessary for teachers to implement and disseminate new ideas about the use of cloud technologies.
14. I am aware of the advantages of cloud technologies and modern means of communication for co-operation between educational institutions.
15. I am aware of the benefits of cloud technology to reduce the cost of education.
16. I am interested in using cloud technologies to improve communication and increase the competitiveness of educational institutions.
17. I adhere to legal and ethical standards when using cloud services and digital content.
18. I participated in joint projects to develop an effective educational environment.
19. I have deployed cloud services for educational institutions.
20. I performed support of CBLE of school.

Diagnosis of the level of the analytical component of ICT competence of future computer science teachers was investigated by testing the ability to use the acquired knowledge and skills in non-standard situations. Students had to demonstrate the ability to perform reflective analysis and correction of their digital activities. We of-fered undergraduates to perform a competency task. They had to develop a long-term plan for the development of CLBE educational institution. The plan implementation algorithm was to contain a detailed description of each stage of CLBE deployment and use in the school.

1. CLBE design:
   - analysis of the state of the school's digital environment;
   - studying the specifics of the activities of teachers and students and determining their needs for the use of cloud services;
   - determining the functionality of cloud services;
   - identification of subjects for which it is not yet possible to implement the necessary functionality;
   - technical audit of the digital environment of damage, including hardware, software, personal devices, availability of Internet access;
   - finding out the financial capabilities of the educational institution.
2. Recommendations for implementation

- informing teachers, students, parents about the structure and possibilities of using CLBE;
- designing a security policy for the use of cloud services and notifying it to all participants in the educational process;
- development and implementation of an algorithm for deploying cloud platforms;
- technical and pedagogical support of activities in CLBE;
- training of school staff, informing the administration about the development of digital technologies.

3. Development prospects
   - determining the scalability of the CBLE;
   - development of an action plan in case of breach of confidentiality of personal data;
   - support for modern standards, protocols, rules for updating all components of the environment;
   - participation in national and international educational projects.

Again, let's check the normality of the distribution of points obtained by students at the search stage. Here are the results of the Kolmogorov-Smirnov test:

- target component: D = 0.070342, p-value = 0.01958;
- content component: D = 0.060965, p-value = 0.07329;
- activity component: D = 0.062046, p-value = 0.06374;
- effective component: D = 0.10837, p-value = 0.000007515.

P-values for motivational and effective components again do not correspond to the normal distribution. P-values for the content and activity components are close to the critical value of 0.05, but still exceed it. Therefore, we will consider the obtained distributions to be normal. Let us check the homogeneity of their dispersions. Here is the result of running leveneTest:

- content component: F value= 0.9305, Pr(>F)= 0.427;
- activity component: F value= 0.5496, Pr(>F)= 0.649

Therefore, we can apply the One-way ANOVA test for the content and operational components. Here are the results of calling the corresponding function.

```
summary(aov(Content~Years,
  data=ResearchingStageData))
#             Df Sum Sq Mean Sq F value
# Pr(>F)
#Years         3    378   126.0   3.612
# 0.0143 *
#Residuals   192   6701    34.9
#Signif. codes: 0 '***' 0.001 '**' 0.01
# '*' 0.05 '.' 0.1 ' ' 1
```

As can be seen from the listing, we have to accept the alternative hypothesis in both cases. That is, there are differences between groups. Figure 2 shows quantile scale diagrams. The dots on the chart show the emissions. In our case, such emissions are low grades of students who have very low grades from the course.

We can assume that the factor that caused these changes is the introduction of the author's methodology. To determinate a set of confidence intervals for the differences between the means of the factor's levels with the specified probability of coverage we have used Tukey's 'Honest Significant Difference' method for both components.

```
TukeyHSD(aov(Content~Years,
  data=ResearchingStageData))
#$Years                 diff        lwr
#      upr     p adj
#2017-2018-2016-2017 0.9925994 -2.1827991
# 4.167998 0.8496254
#2018-2019-2016-2017 2.3033885 -0.7508257
# 5.357603 0.2090704
#2019-2020-2016-2017 3.7281806  0.6022937
# 6.854068 0.0121774
#2018-2019-2017-2018 1.3107890 -1.7611233
# 4.382701 0.6863632
#2019-2020-2017-2018 2.7355812 -0.4076003
# 5.878763 0.1122965
#2019-2020-2018-2019 1.4247921 -1.5959128
# 4.445497 0.6133838
```

For the content component, the differences between the values of the 2016–2017 and 2019–2020 academic years are statistically significant changes.

```
TukeyHSD(aov(Operational~Years,
 data=ResearchingStageData))
#$Years                 diff        lwr
#      upr     p adj
#2017-2018-2016-2017 0.06336725 -2.9224371
# 3.049172 0.9999401
#2018-2019-2016-2017 3.45547675  0.5836212
# 6.327332 0.0111944
#2019-2020-2016-2017 4.33000434  1.3907555
# 7.269253 0.0010348
#2018-2019-2017-2018 3.39210950  0.5036125
# 6.280606 0.0140729
#2019-2020-2017-2018 4.26663709  1.3111262
# 7.222148 0.0013706
#2019-2020-2018-2019 0.87452759 -1.9658195
# 3.714875 0.8552859
```

From the above listing, we can conclude that almost all components of the model had the skills to

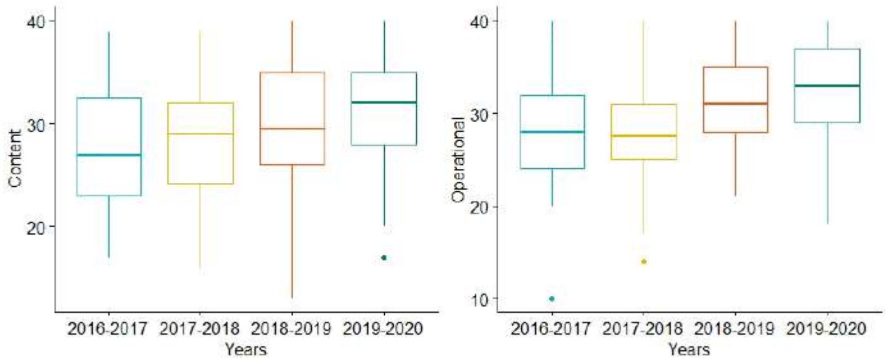

Figure 2: Range diagrams of average values of content and operational components.

create, deploy and use cloud technologies.

To assess the development of the target component, we use the Kruskal-Wallis test. Here are its results:

- Target by Years Kruskal-Wallis chi-squared = 7.0967, df = 3, p-value = 0.06888;

From the obtained test data, we can still accept the null hypothesis that there are no statistically significant differences between the groups. Therefore, we cannot draw a reasonable conclusion about the impact of our model on the development of the motivational component of ICT competence.

For the reflex component, the results of the Kruskal-Wallis test are as follows:

- Effective by Years Kruskal-Wallis chi-squared = 18.66, df = 3, p-value = 0.0003213;

In this case, we accept an alternative hypothesis about the existence of differences between groups of students. In order to make multiple comparisons between groups, possibly with a correction to control the experiment wise error rate we have performed Dunn's Kruskal-Wallis test. Here are its results:

```
PT = dunnTest(Effective~Years,
 data = ResearchingStageData)
PT
#          Comparison           Z
#      P.unadj       P.adj
#1 2016-2017 - 2017-2018  0.08638957
# 0.9311567356 0.931156736
#2 2016-2017 - 2018-2019 -1.70307343
# 0.0885543273 0.177108655
#3 2017-2018 - 2018-2019 -1.78256141
# 0.0746577266 0.223973180
#4 2016-2017 - 2019-2020 -3.66052102
# 0.0002517029 0.001258514
#5 2017-2018 - 2019-2020 -3.72765494
# 0.0001932697 0.001159618
#6 2018-2019 - 2019-2020 -2.06601565
# 0.0388270019 0.155308008
```

The results of this test show that there are differences between 2016-2017 – 2019-2020 and 2016-2017 – 2019-2020 pairs of years. Therefore, we can conclude that participation in a real project had a positive impact on students' integrated under-standing of the role of cloud technologies in the digitalization of the school learning process.

5 CONCLUSION

The problem of the use of cloud computing in the process of training future computer science teachers is actual and needs further research. Training for the use of cloud technologies should be carried out throughout the student's study period. The model of application and studying of cloud technologies in the process of training of future teachers of informatics contains target, content, technological and resultant component. The content component realizes during 3 stages such as.

1. Cloud technology is a means of education.
2. Cloud computing is the object of study.
3. Cloud computing is a development tool.

The study in the first and second stage should be done in the bachelor's degree. Stage 3 can be implemented as a master's program.

The current level of cloud computing development makes the project method demanded and effective. Participation in the proposed projects contributes to the development of students' skills of independent and responsible work with cloud technologies. They have opportunity to focus on results. Students can recognize themselves as successful network administrator, programmer, teacher.

Our model provides combination of face-to-face and online learning allows teachers to make use of advantages offered by the cloud base learning environment.

According to the results of the experiment, the hypothesis of a positive impact of the designed CLBE on the development of ICT competence of future computer science teachers was confirmed. Participation in the real project had a significant impact on students' integrated understanding of the role of cloud technologies.

Qualitative changes in the dynamics of development of components of ICT competence of students using the proposed model confirmed the effectiveness of the author's methodology.

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Familiarity with Free Software through Online Services

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Abstract: The article considers the use of online services in the study of free software. Free software is based on the philosophy of freedom and the right to intellectual creativity. To date, a significant number of software products have been created and distributed through the repository, but they are not used in educational activities. The study allowed to clarify the factors that promote and hinder the use of free software in educational activities. Based on questionnaires, analysis of open data, the work of researchers on the use of free software provided an opportunity to draw conclusions about the feasibility of using free software in educational activities. The article gives examples of the use of free software in educational activities. To get acquainted with free software, it was useful to use online resources, which is the purpose of our study.

1 INTRODUCTION

Modern teaching methods involve the use of information and communication technologies (ICT) in the educational process. The use of ICT has not only changed the methods of traditional learning, redistributed priorities between forms of learning, but new forms of learning have emerged. For any method or form of training that uses high information technology, software is required, without which the technologies lose their meaning. From the interactive whiteboard controller application to multimedia application creation and distribution programs on the World Wide Web.

Free software is a significant feature of the computer industry. Launched as a philosophical concept, free software has not only found its adherents, but also has a large number of software tools used in various directions in its arsenal. The pedagogical universities are use in educational activity: systems for the organization of distance education Moodle, ILIAS, ATutor, Sakai is not an exception; computer mathematics systems Maxima, GNU Octave, GAP, SageMath, Scilab, SPP; GIMP, Inkscape graphics packages; Apache OpenOffice, LibreOffice office packages. The question remains about the full and systematic use of free software in the educational activities of professionals.

Common problems of free software, legal and philosophical aspects of its existence and use are covered in (Raymond, 1999; Stallman, 2015; Tanenbaum and Bos, 2015). In Ukraine the problems of using free software in the education system are highlighted in (Fedorenko et al., 2019; Habrusiev, 2003; Horoshko et al., 2010; Khakhanovskyi and Tonevytskyi, 2005; Panchenko, 2010; Teplytskyi and Semerikov, 2003; Velychko et al., 2018; Zlobin, 2011). The current state of the issue of the use of cloud technologies in educational activities is shown in (Glazunova et al., 2020; Kholoshyn et al., 2020; Kolgatin et al., 2019; Korotun et al., 2020; Lytvynova, 2018; Merzlykin et al., 2017; Nosenko et al., 2019; Oleksiuk and Oleksiuk, 2020; Popel and Shyshkina, 2019; Shyshkina and Marienko, 2020; Symonenko et al., 2020; Valko et al., 2020). However, the problem of in-depth exploration of free software capabilities and widespread use in educational activities remains. One possible solution to this problem is to study free software using online services.

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2 RESEARCH OBJECTIVE AND METHODS

Free software developers have a passive marketing policy regarding the distribution of their product. High-quality and useful free software remains unknown to a wide range of users. The purpose of this article is to explore the factors by which free software is chosen to train pre-service teachers and the factors that do not. Moreover, we present the possibilities of online acquaintance with free software, which can be used by pre-service teachers to include it in their own educational trajectory. This module is offered as a section of the author's course "Application of information and communication technologies in educational institutions" at Donbas State Pedagogical University (https://ddpu.edu.ua/) for educational programs Secondary Education (Mathematics) and Secondary Education (Physics) of the second master's level of education at the Faculty of Physics and Mathematics. The vision of Donbas State Pedagogical University is that the university is "an educational, scientific and cultural leader of Eastern Ukraine, which implements state innovation policy in education in accordance with market demands and trends in the digital society of the XXI century, guided by universal and national values, principles of democracy and European integration, and creates conditions for the formation of highly educated, competitive professionals with an active civil position, patriots of Ukraine!".

Research methods are: analysis of publications on the use of free software in educational activities; analysis of concepts of application of information and communication technologies in education; analysis of free software related to the training of pre-service teachers; systematization and generalization of research information.

3 RESULTS OF THE STUDY

A characteristic feature of our time is the transition from a traditional to an integrated approach to learning. However, this is not a complete rejection of the acquired pedagogical experience, but only a harmonious combination of approaches, forms and methods of scientific work, research and implementation of sound ideas, methods and techniques of forming a system of higher pedagogical education.

Consider the general directions of use of information and communication technologies, adapting them to the use of free software in the training of pre-service teachers of mathematics, physics and computer science. Such areas include:

- *creation of new pedagogical technologies and teaching aids*. Information and communication technologies based on the use of free software are the technological basis for developing conditions for effective use of ICT in the educational process of pre-service teachers of mathematics, physics and computer science, which will eliminate a number of methodological difficulties at all levels of education and training.
- *increasing the democratization of education.* The process of modern times, covering all aspects of the life of educational institutions. It is based on self-organization, cooperation, openness, diversity and the principle of equal opportunities through the use of free software. This is a long but long-awaited process. The purpose of this process is to normalize relations between society and educational institutions, covering all levels of the internal structure of education and streamlining relations between all parts of the educational process.
- *self-education and lifelong learning.* Information and communication technologies of education, built on free software, are one of the main means of forming the ability to education and self-education in the training of pre-service teachers of mathematics, physics and computer science, especially given the rapid continuous process of informatization of society. The use of ICT – direct feedback, computer visualization of educational information, archival storage of educational and scientific information with the possibility of its transmission and use, automation of computational and information retrieval activities with the possibility of multi-act repetition – creating a prerequisite for intensification of the educational process.
- *individualization of training.* Maximum consideration of individual needs and capabilities of the individual, flexible adjustment to his needs and interests. It is based on the use of specific educational technologies, modern teaching methods, technical means and methods of information transfer, information and communication technologies, electronic educational resources. Individualization of training of pre-service teachers of mathematics, physics and computer science is achieved through such forms of e-learning as distance learning, blended learning, mobile learning, synchronous and asynchronous learning tools, mass open online courses, use of free software and more.

- *increasing the level of electronic educational resources.* Due to the introduction of ICT in the educational process it becomes possible to use educational, scientific, informational, reference materials and tools developed in electronic form using free software, reproduced by electronic teaching aids and necessary for effective organization of the educational process of pre-service teachers of mathematics, physics and computer science, which contributes to the filling of the educational process with quality teaching materials.
- *the creation of a favorable psychological climate* is achieved by taking into account the psychological and physical capabilities of pre-service teachers of mathematics, physics and computer science, direct communication with teachers, free schedule, self-determination of workload, availability of licensed software. ICT such as chats, mass open online courses, distance learning, blended learning, mobile learning, webinars, web conferencing etc. can be used in this direction.
- *software and didactic support of self-educational activities* is to develop and implement in the educational process of pre-service teachers of mathematics, physics and computer science electronic educational resources, the formation of skills in using ICT in self-educational activities based on free software, planning research, creating motivational basics, use of information and communication technologies for search, processing, storage, transmission and processing of information.
- *development of creative abilities of students.* Knowledge and skills stimulate those who want to learn to search for creative activity. One of the mechanisms to stimulate creative activity and in accordance with the development of creative abilities of pre-service teachers of mathematics, physics and computer science is to provide a new, more convenient and powerful tool in the form of information and communication technologies based on free software. Free software can not only make it much easier to achieve a goal or solve a problem, but also a powerful way to put forward, validate, and refute new creative ideas.
- *community expansion.* Search for the necessary educational information on the resources of the Internet; communication with like-minded people and professionals who study at their own request; participation in communities of free software developers creates the preconditions for expanding the community of like-minded people. The Internet is the most powerful tool for "networking between members of the open electronic community, providing them with virtual cooperation, an environment that provides information resources and services to all users without exception for an unlimited range of applications" (Bykov, 2011) and is a powerful practical experience of communication, search , information exchange and application of free software for pre-service teachers of mathematics, physics and computer science.
- *raising the cultural and educational level.* The cultural level of the individual is manifested only in the activity, therefore, to consider information culture as a quality is appropriate from the standpoint of the ability to work with information coming from different sources, has a different meaning and different forms of presentation. Increasing the role of search, transmission, storage and processing of information encourages the formation of information competence in pre-service teachers of mathematics, physics and computer science through the widespread use of free software.
- *continuous professional development.* Thanks to such forms of learning as distance, blended and mobile, mass open online courses, etc., pre-service teachers of mathematics, physics and computer science get the opportunity to continuously improve their skills and level of self-awareness in certain fields. The study of information processing technologies based on the use of free software stimulates both to maintain their own knowledge and skills in use, and to the development of free software. The basis of such training is to adjust the learning process to the needs and capabilities of those who are taught and who do not have the opportunity to attend classes organized in the traditional form (lectures, seminars, laboratory and practical work, colloquia, etc.), and study at a convenient time, a convenient place, a convenient pace, which provides great advantages also for those wishing to continue their education without separation from production, to study in a certain educational institution, with a certain teacher, etc.
- *exchange of experience and creation of conditions for creative activity.* Virtual educational communities are a common and popular phenomenon today. They are not limited to a single educational institution, but have a wider range of activities, covering different levels, target groups and structures of the educational system. Virtual educational communities are aimed at gaining new knowledge; training and improvement of ICT skills; exchange of experience; discussion of professional activity; joint development and im-

provement of teaching methods, teaching aids, etc. and will become a powerful practical assistant for pre-service teachers of mathematics, physics and computer science in their professional activities.

It should be noted that the content of virtual space in general, and educational in particular, is changing very rapidly; exchange of creative ideas and their implementation allow not only to widely reveal the didactic potential of ICT in the training of pre-service teachers of mathematics, physics and computer science, but also stimulate creative action. Of particular importance is the use of ICT in the educational process of pre-service teachers of mathematics, physics and computer science takes into account and the development of informal, creative components of thinking: the implementation of problem situations or problem setting; self-determination of criteria for selection of the necessary operations that contribute to the solution of situations or tasks; generation of assumptions and hypotheses in the process of finding the main idea of the solution; material interpretation of a formal solution, etc.

Open Education Ideas provide free access to e-learning resources for everyone to learn. Such access is provided by ICT based on free software.

Our research has allowed us to identify the factors that hinder and facilitate the use of free software. One of the stages of the study was to conduct an anonymous survey of higher education teachers regarding the use of free software in their professional activities. The developed questionnaire as a form was made freely available (https://goo.gl/forms/F0BVkSnvwpHTo6H82) using Google Forms, a link to which was circulated via the "Kryvyi Rih conferences and workshops" (https://groups.google.com/group/cc_seminar) and "Scientific journal Physical and Mathematical education" (https://groups.google.com/group/fmo-journal).

The data collected to date have allowed us to determine the following results. 93% of respondents teach science and mathematics. Young teachers, who already have experience in teaching, predominate by age (figure 1). 92% use free software in their professional activities. 95% recommend free software to their students for extracurricular activities.

Considering the benefits of using free software, the following were highlighted for conducting the questionnaire:

- legal (licensed purity, non-discrimination, etc.);
- technical (open standards, increased security, vendor independence);
- training (providing the necessary functionality, open source);
- social (trend, modern gadgets).

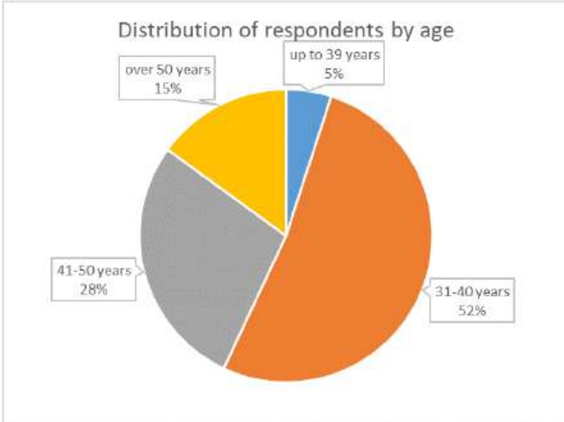

Figure 1: Distribution of respondents by age.

Respondents identified the following factors as facilitating the use of free software (figure 2): legal preference was given the highest importance (82,4%). This result is predictable. According to estimates of the Software Alliance (bsa.org, BSA GLOBAL SOFTWARE SURVEY 2018), 80% of the software used in Ukraine is not licensed purity.

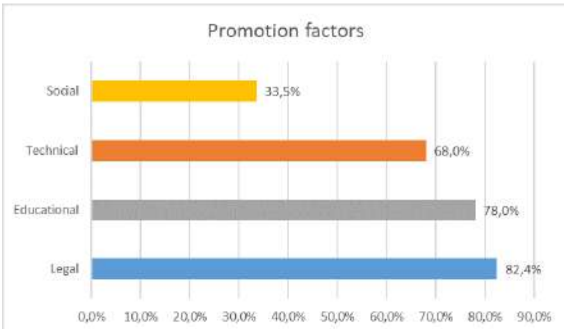

Figure 2: Factors promoting the use of free software.

78% of the respondents chose among the advantages of free software its educational attractiveness. This result indicates that sufficient free software is available for educational activities. Also important is the availability and openness of software source code.

The analysis of the survey answers indicates that there are technical advantages of using free software in the process of training future professionals. This is noted by 68% of respondents. Open storage standards are an important factor in the software selection process. This gives you confidence in the continued use of your own work. User gains independence from software developers.

The low percentage (33,5%) belongs to social preferences. The reason is marketing policy. When

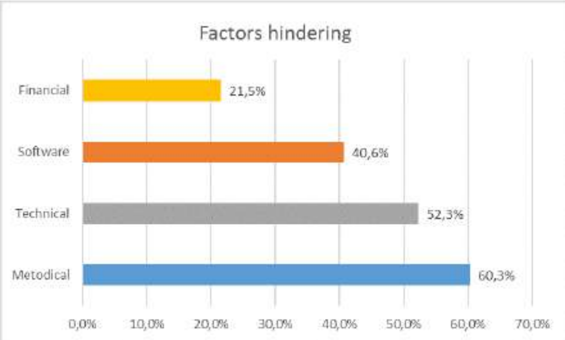

Figure 3: Factors interferenting the use of free software.

promoting new high-tech devices, it does not emphasize that their work is based on free software because of its low social popularity.

The survey revealed a number of shortcomings in the use of free software in educational activities (figure 3). We identified the shortcomings in the following groups:

- financial (funds for migration, training, etc.);
- technical (changing the format of existing data, support for peripherals);
- software (lack of specialized software);
- methodical (lack of methodological support for application).

The lowest percentage (21,5%) belongs to financial expenses. This low level of concern about financial issues is due to the lack of responsibility for the use of unlicensed software.

40,6% of respondents are not aware of the existence and localization of specialized free software. At the same time on the resources GitHub.com (more than 100 million projects), SourceForge.net (502,000 projects), openhub.net (498,000 projects), bitbucket.org (170,000 projects), launchpad.net (44,000 projects), Savannah.gnu.org (4,000 projects) posted a large number of software products under free licenses.

The downside of free software is technical issues. These include the transition to new file formats (open file formats) and software for working with peripherals. This concern was expressed by 52,3% of respondents. Open file formats are currently well developed. Proprietary and closed form owners are taking steps to legalize their openness due to the development of open file format standards. User-generated data can be stored and used for a long time. Users need to have confidence that they can be used for a considerable period of time. Own data must be created using open file formats.

Currently, free and open file formats are available in proprietary software as both input and output data streams. Moreover, standards for open file formats are being actively developed by proprietary software owners. This policy allows you to extend the life of your own documents and not be tied to a particular software developer.

A technical problem is the variety of peripherals and the lack of peripheral software. Peripheral developers are trying to keep the technology developed secret. The necessary technical information is not provided for public use. This fact makes it impossible to create free software for peripherals.

The biggest drawback is the lack of methodological support for the use of free software in educational activities. It was identified by 60,3% of respondents. The lack of free software at the beginning of the informatization led to the installation of proprietary system software as the base. Therefore, proprietary application software has also become widespread. Methodological support for the use of software exists in most proprietary software. Today, the situation with the use of free system software has not improved. According to the StatCounter resource (http://gs.statcounter.com), only 1,84% of desktop computers in the world have the Linux operating system installed.

The situation is similar in Ukraine. Only 2,66% of desktop systems are running Linux. However, the situation is beginning to change. The results of scientific and methodological research on the use of free software in education are presented at the annual FOSS Lviv conference (http://conference.linux.lviv.ua/) and more (Velychko, 2014, 2015). Thus, at the Luhansk Taras Shevchenko National University, pre-service teachers of Mathematics, Physics and Computer science study the Linux operating system, the Maxima computer mathematics system and the Lazarus, Geany programming environment. At Pavlo Tychyna Uman State Pedagogical University, the course “Computer Network Administration” is taught on the Linux operating system. Nizhyn Mykola Gogol State University uses the OpenOffice.org software, Hot Potatoes, to study the subject of Electronic Information Processing. The basic discipline of “PC operating systems” is taught using the Linux operating system as a complete alternative to the proprietary Windows system. The courses “Using Information Technology in Education and Science”, “School Computer Science and Teaching Methods” demonstrate the possibilities of using OpenOffice.org and Scribus as an alternative to Microsoft Office, GIMP as an alternative to Adobe Photoshop, Inkscape as an alternative to CorelDraw and more.

GeoGebra Institute operates at the Department of Informatics at H. S. Skovoroda Kharkiv National Pedagogical University. The National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic University" operates the "Linux Professional Institute" (LPI). At the Bogdan Khmelnytsky Melitopol State Pedagogical University, there are such disciplines as "UNIX-like operating systems" and "Programming for open systems" in the bachelor's curriculum.

At the Poltava V. G. Korolenko National Pedagogical University is widely used by GIMP when teaching Computer Graphics and Design, and geometry is supported by Maxima Computer Mathematics. The Maxima computer mathematics system is also widely used in the teaching of students of Physics and Mathematics at Ivan Franko Drohobych Ivan Franko State Pedagogical University.

At Sumy State Pedagogical University named after A. S. Makarenko uses software products such as GeoGebra, Dr Geo, C.A.R., Kig and KSEG to train future math, physics and computer science teachers. At the National Pedagogical Dragomanov University systems of computer mathematics Maxima, Sage, Scilab, Scidavis and many others are used in the study of the disciplines of mathematical and informative cycles. Teachers of Kryvyi Rih State Pedagogical University base their teaching on the Maxima computer mathematics system for basic mathematical training of pre-service teachers of mathematics, physics and computer science. All of the above software products are free software products.

The expediency of using free software in the educational process of future professionals is quite high. Free software gives freedom to its users to choose to use and study both the free software products themselves and their applications. It is a direct factor in stimulating the desire for learning and self-education. The use of free software in the training of future professionals will increase the level of information culture, will teach themselves to choose forms and methods of education, will form skills for the use of free software in further professional activity, will be able to be competitive in the labor market and meet the requirements of social ordering information society in the modern specialist.

To get acquainted with the free software, it is not necessary to download it to your own personal device. You do not have to visit the computer systems labs where the appropriate software is installed. Cloud technologies make it possible to use the software as a network service. OffiDocs Cloud (https://www.offidocs.com/) is a flexible and powerful platform. It allows you to browse the web with applications using only a web browser. OffiDocs provides users with Internet applications for any device (desktop, tablet, mobile, etc.) such as LibreOffice, GIMP, Dia, AudaCity, OpenShot and many more through a web browser.

A prerequisite for using a cloud service is logging in with an ID. It is available from any cloud application. Cloud applications are categorized as productivity, images & graphics, video & audio, messaging, education, games, utilities, programming.

Each of these sections of the cloud application is noteworthy. Just as interesting are mobile apps, extensions, resources and templates. Let's take a closer look at the cloud-based LibreOffice suite of services included with the file manager. It is worth noting that there are two options – the first (figure 4) is adapted for use in browsers, and the second, launching applications with Gnome interface with image translation in the frame of a hypertext document. Cloud service integration includes integration with Google Drive and Dropbox cloud file repositories.

With the ability of a cloud-based environment to study free software, it becomes available to perform standard operations to create electronic educational resources. There is a possibility to use various ways of registration of the textual information (styles, fonts, font sizes, etc.). Text documents and presentations can be supplemented with illustrations (you can use the resource http://editor.pho.to/en/edit/ to process the illustrations). Once created, documents can be downloaded to your own device in ODT, PDF, and more. With http://odfviewer.nsspot.net/ you can view downloaded documents in ODT format. Use the https://smallpdf.com/edit-pdf service to view and compare PDFs visually.

Image creation, video editing and audio editing programs are just as functional. The typical task of using this cloud application is to create an online educational resource for one of the training topics using the learned applications.

Another cloud service that allows you to get acquainted with free software is the service https://www.rollapp.com/ (figure 5). In this dream, educational applications, utilities, office applications, games, graphics applications, development programs are available to users. Free software is available for use in this cloud after user registration. In addition, there is a rating system for evaluating the available software by users.

There are a sufficient number of distance learning support systems Moodle, ILIAS, aTutor, Claroline, Dokeos, Fedena, Sakai and many others. Moodle is created as a platform for technical support of distance learning, respectively, it provides mechanisms to address issues that traditionally arise before teachers and students in a distance learning situation: communication between teacher and students, communication

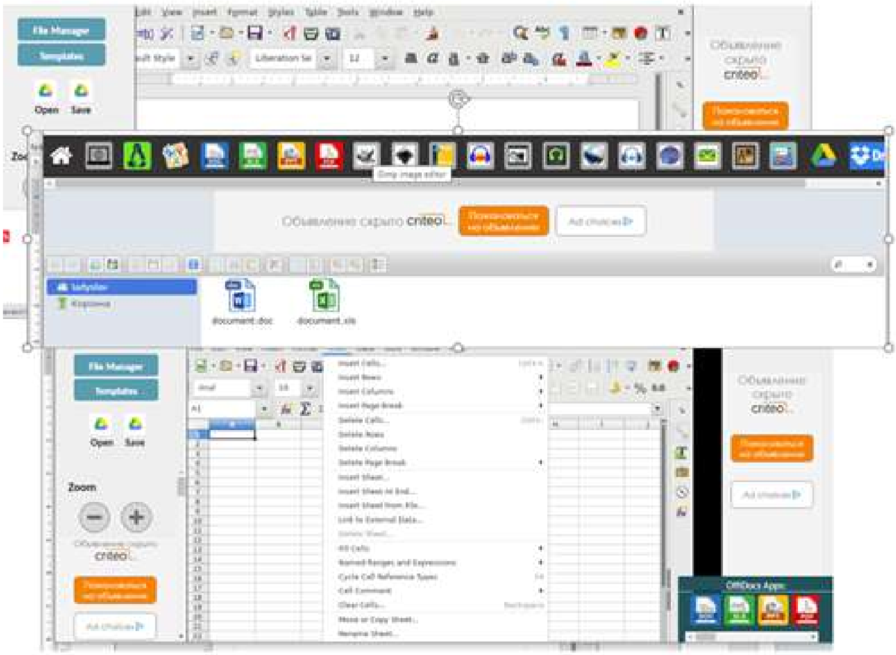

Figure 4: An example of how a file manager works in LibreOffice.

between students, access to teaching materials, implementation tests, planning and organization of the teacher and students.

Within the system, all learning materials and user activities are grouped into so-called "courses" – basic units that may or may not correspond to the concept of "course" or "discipline" within the traditional learning process (for example, to teach students of different specialties and the same discipline will most likely need to create several courses). The course has the following properties:

- information content, broken down by topic or week,
- a set of participants, among whom one or more are usually endowed with additional rights (teachers),
- statement of the results of control measures,
- calendar of events.

From a visual point of view, the course can have its own style of page design (theme) and its own interface language (among those languages installed on the server).

The basic types of materials and activities that may consist of the course include the following:

- static materials (text and web pages, documents of various formats, audio and video materials, other files);
- interactive elements (forums, chats, tests, tasks, lectures, wiki, blogs, databases, polls, other components).

The capabilities of the system can be expanded and supplemented by installing additional modules.

Get acquainted with the capabilities of the Moodle system using the test system http://qa.moodle.net as a teacher. To do this, use the "teacher" login and "test" password. In the Activity examples section, add a new topic to the forum. See examples of objects such as lessons, tests, tasks, and resources. Keep in mind that your presence on the site is limited (figure 6).

ILIAS (short for Integriertes Lern-, Informations- und Arbeitskooperations-System, www.ilias.de) is an open source distance learning system distributed under the GNU GPL license. The system appeared in 1998 and has been developing quite actively since then.

ILIAS has a very wide range of functionality, has a large number of tools for communication: forums, chats, blogs, podcasts, as well as an internal messaging system. In addition, ILIAS can be very successful in collaborating with features such as grouping users, sharing files, including sharing any files, and wiki tools.

Of course, at a high level and the capabilities of the system in terms of e-courses and tests. Courses can be formed in the simplest form in html format or taught in the form of specific files. But in addition, basic international standards such as SCORM 1.2, SCORM 2004, AICC are supported. The sys-

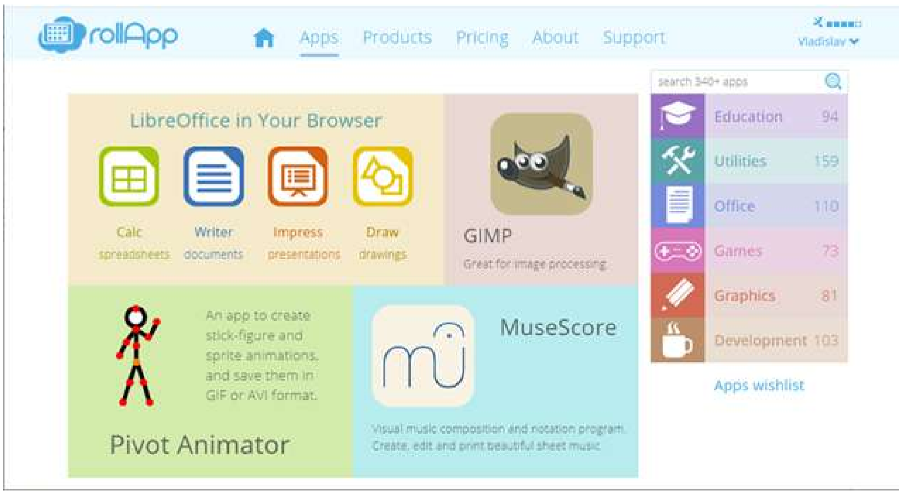

Figure 5: RollApp cloud service.

tem has a test designer that supports different types of questions. It is also possible to import into the system of external tests or export them in IMS QTI format. Course and test management capabilities, including course review and reports, are also quite extensive.

In addition, the system can use tools such as: Personal workspace, News, E-portfolio, Calendar, Personal notebook and more. To install ILIAS, you need an Apache server with PHP support and a MySQL database. ILIAS has been translated into many languages, including Ukrainian. Get acquainted with the capabilities of the ILIAS system using the test system http://demo.ilias.de using "gwyneth" login and "ilias-demo" password (figure 7).

ATutor is a Web-based Learning Content Management System (LCMS). Its use allows teachers to easily organize various training courses. Students receive an adaptive and simple learning environment. The new system will not give the administrator any special worries either. Appearance can be changed in just a couple of mouse clicks, the availability of source code and open tools used to build a course server, allow you to make more serious changes in case of emergency. For everything you need to create and manage courses and the learning process, it includes messaging tools. Particular attention is paid to security. With the help of additional modules you can increase the functionality. The choice of the latter is wide, from payment, to work with photos, exchange of information with other educational systems, conferences and others.

In addition, from the very beginning, the developers have taken a course to support the product of various standards, which would allow in the future to easily integrate third-party developments. So ATutor's first LCMS is fully compliant with the W3CWCAG accessibility specification (Web Content Accessibility Guidelines, http://www.w3.org/WAI/WCAG1AA-Conformance) in accordance with these recommendations, the resource should be available, including for users with various disabilities health. Also, compliance with W3C XHTML 1.0 specifications ensures that ATutor will work or integrate with any other applications that support the standards as needed. Some such applications are available on the project website and about them below. To be able to use courses written for other e-learning learning systems, the system supports the IMS (InstructionalManagement Standards, www.imsproject.org) and SCORM (SharableContentObject ReferenceModel, www.adlnet.org) specifications.

Learn about the capabilities of the ATutor system using the test system. In the ATutor Demo Course. Use this course to review available materials, edit existing text files, and post on the forum. There is a public demo installation of ATutor which is shared with others and resets itself hourly. You can access it by visiting the following link https://s1.demo.opensourcecms.com/s/95 login "opensourcecms" and password "opensourcecms" (figure 8).

Global biological threats pose to pre-service teachers not only the need to have distance learning systems but also the means to create e-learning resources. Among the free software, there are various tools for creating electronic educational resources from programming languages to specialized software for this activity. Such systems include Xerte Online Toolkits and eLearning XHTML editor.

Xerte Online Toolkits or XOT (https://www.xerte.org.uk/index.php/en/) is software developed in the academic environment of the University of Nottingham and distributed under the Apache License. The main purpose of a full-featured XOT development

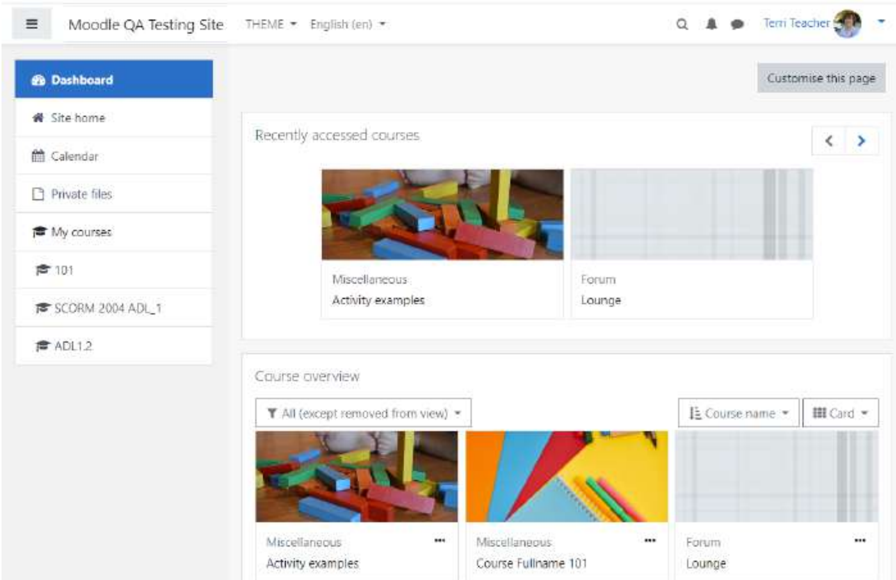

Figure 6: Moodle QA Testing Site.

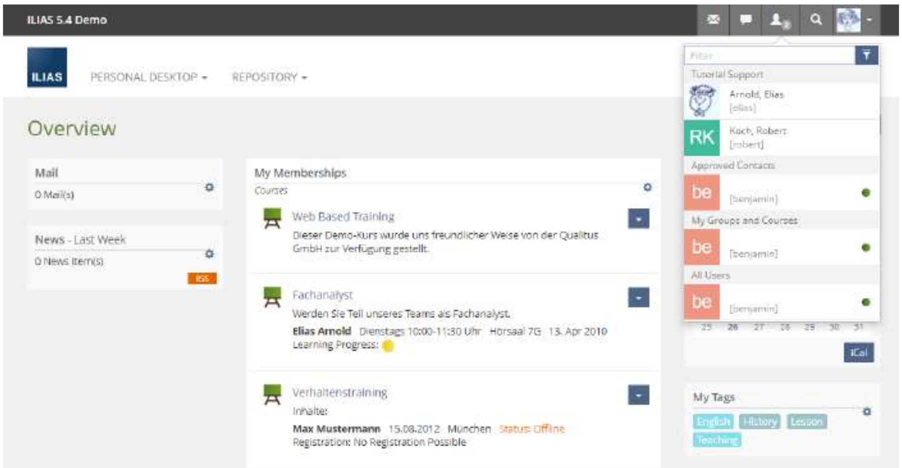

Figure 7: ILIAS Testing Site.

environment is to create interactive learning objects. The current version of XOT 3.9 provides the opportunity to create modern training courses with a rather complex structure and a variety of, including interactive, learning objects, the development of which does not require in-depth knowledge in the field of programming. To develop such a course, the author only needs to use a browser, and all operations to create training courses are performed using intuitive actions. In addition, demonstration examples are offered to get acquainted with the capabilities of the system and its testing.

eLearning XHTML editor or eXe (https://exelearning.net/en/) is a web-tool for designing, developing and publishing web-oriented teaching materials. The eXe system was developed in the academic environment of the University of Auckland and the Auckland University of Technology. Development is now supported by government agencies and companies in Spain and other countries. It can generate interactive learning material in XHTML or HTML5 format and provides the ability to create learning resources that contain text, images, interactive components, image galleries, or multimedia clips. Such files can be exported to various digital formats to be used independently on the instructor's website. They can also be integrated into a learning management system (LMS). The current version of eXe 2.5.1 supports such formats as IMS Content Package, SCORM 1.2, SCORM 2004, IMS Common Cartridge formats,

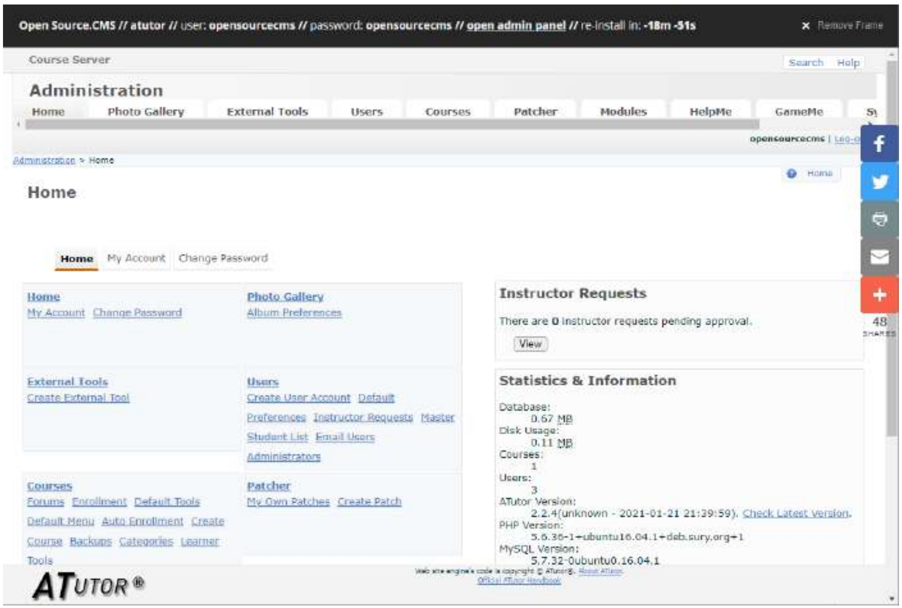

Figure 8: ATutor Testing Site.

ePub3 or web-resource in HTML5 format.

Since the purpose of our study was to get acquainted with free software, we provide at the end of the resource, which contains links to available free resources and free programs in the section "Best Free Online Applications" – https://www.techsupportalert.com/.

4 CONCLUSIONS AND PROSPECTS OF FUTURE RESEARCH

Research on the application of information and communication technologies is always modern and multifaceted. Software developers create and upgrade existing computer programs on a daily basis. Forms and methods of application of information and communication technologies in educational activity change. The given directions of application of the free software in educational activity and the carried-out researches outline the directions of the further researches on this question.

The results of many years of use of the OffiDocs cloud service at the Faculty of Physics and Mathematics of Donbas State Pedagogical University testify to its wide opportunities to get acquainted with free software and its application in the educational activities of pre-service teachers of mathematics, physics and computer science. Having an alternative to cloud applications from Google and Microsoft allows you to study information processing technologies, rather than certain software. You do not need to study the software interfaces, because they are intuitive. The latter provides an opportunity to fundamentalize training in information and communication technologies and prepare future professionals for further professional activity.

The opportunity to get acquainted with free software with the help of online services not only expands our understanding of existing applications, but also provides an opportunity to initially evaluate its functionality.

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The Use of Moodle in the Teaching of Philosophy and Distance Learning

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Keywords: Philosophy, Critical Thinking, Soft Skills, Reflexive Learning, Test Control, Moodle, E-Learning Environment, Education During a Pandemic, Distance Learning of Philosophy, Risk Society.

Abstract: The paper highlights the importance of philosophy and special philosophical disciplines for the modern general education, assuming their role in the soft skills training, and more concretely in developing critical thinking in students. However, the emerging trend of reducing the university philosophy courses can make it difficult to fulfill this role in full. In this context using the distance learning tools and learning management systems can help to provide an appropriate educational environment (also in view of the current pandemic situation) to ensure the sufficient level of learning outcomes in philosophical literacy and critical thinking skills. Moreover, the modern e-learning tools and technologies can facilitate the involvement of students into the global educational space and promote development of their lifelong learning skills. In elaborating a virtual learning environment for philosophy courses, one has to take into account certain features of philosophical disciplines, which are instrumental in their structure and may cause some difficulties by its implementation. Namely, the learning outcomes in philosophy courses may not easily be parametrized, philosophical questions often allow for multiple alternative answers, and philosophical discourse is essentially communicative. Remarkably, the Moodle learning management system is well suited for addressing these issues and enhancing the learning process. To this effect we propose various task types to maintain high standards of learning achievements: test control in the flipped classroom, control of work with primary sources, control of self-study, test implementation of interim thematic control. In this way the Moodle system can well be regarded as an efficient virtual tool for an on-line support of a general philosophy course. Still, one should be fully aware that this tool can only play a supporting role and cannot entirely replace a substantive philosophical dialogue actually occurring either in a "physical" classroom or by means of a video-conference platform (such as Zoom, Google Meet, etc.). Modes of study, directly related to communication, are integral part of the methodology of philosophy and its teaching, since philosophy itself is a discursive and pluralistic field. Nevertheless, taking into account the features of the discipline, it is possible to provide not only an effective test control, but also to implement a number of general educational goals, such as updating the basic knowledge, memorization, activating the cognitive interest, developing the ability to reason, and – last but not least – the skill of acquiring and assimilating information. The paper presents a comparative statistical analysis of the student academic achievement by studying philosophy in a lecture room and distantly during the pandemic.

1 INTRODUCTION

Reforming of the education system should be provided for in response to public demand and information standards of the world educational culture, which is focused on the formation of key competences of participants in education (Shokaliuk et al., 2020). In education, the process of transformation requires revision and reassessment of the humanities, especially philosophy, as it should be regarded as a powerful methodological platform, which leads to successful solving of the tasks outlined in the national educational strategy.

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1.1 Outlining the Problem

Scientific and technological advance shows a notable paradox: on the one hand, society seeks accelerated development to achieve pragmatic results; on the other hand, this advance causes dangerous transformations of biosocial reality characterized by low levels of prediction, uncertainty about the future events. The constant growth of life threats is a reason to assess these trends as "risk trends". In our opinion, modern education is not relevant without considering the situation of risk as a "measure of unexpected danger" (Giddens, 1990). We view risk in its positive sense as a "rational way of mastering reality", which is the prospect of rational construction of a new type of educational culture, including a "diversification" constant. Thus, on the one hand, the 2020 pandemic caused long-term social isolation, which led to a clear understanding that social stability, is the result of a comprehensive justification of "protective", premature social and, in particular, educational strategies, and, on the other hand, it showed new tools and opportunities, emphasizing the effectiveness of distance learning (Polhun et al., 2021).

What are the trends and resources of educational culture focused on preserving the educational base in the current situation? Undoubtedly, a high-quality, balanced resource of distance learning justified itself as a full-fledged type of education, having been developed from, in a certain sense, experimental education to a global educational network. In 1969, the first university of distance education, the Open University, was opened in Great Britain. Nowadays, it is an educational centre playing an essential role in the social and economic life of the country (Open University, 2021).

In the UK, the Quality Assurance Agency for Higher Education praised the quality of the educational process at universities, involving a wide range of distance learning technologies. Widespread use of "distance technologies" has formed the paradigm of "distance education" with the following concepts: "distance reaching", "emergently organized distance teaching", "test tools", "independent assessment", "distance learning", "distance counseling", "e-learning", "blended learning", "online learning platform", "learning management system", etc (Syvyi et al., 2020; Vlasenko et al., 2020). The centres of distance education work successfully in other countries.

The pandemic situation has demonstrated a fine line between social and biological. As Badiou (Badiou, 2020) notes: "An epidemic is complicated because it is always a point of contact between natural and social definitions. Its full analysis is transversal: it is necessary to understand the points where these two definitions intersect and derive the consequences from that".

In our opinion, the new type of education presupposes the existence of a high-quality educational environment, which takes into account past and present experience, provides qualitative analysis of advantages and disadvantages, and successfully combines traditional and modern educational achievements with current social values. Thus, modern education type presupposes the existence of philosophical discourse, focused on the formation of critical, systemic, and other kinds of thinking, relevant sections of social ethics, especially, pedagogical, environmental, information culture in combination with e-learning technologies.

For it is necessary to introduce e-learning tools in the educational process, the educators should take into consideration the specificity of their implementation that allow to master the strategy of teaching philosophy on the basis of the online learning environment. Thus, there is a need to outline the educational perspectives of philosophy teaching with the involvement of online learning environment and to identify the particularities of the use of test tools in this process.

The experience of the rapid transition to distance education has well demonstrated the peculiarities, pros and cons of the distance learning management and, in particular, in the teaching of philosophical disciplines. On the one hand, these features are already familiar. On the other hand, new characteristics became apparent due to the peculiarities of the social situation, the features of the national education system and the peculiarities of the subject itself.

Therefore, in our study, based on our work (Abdula et al., 2020) we aim to consider the general features of Moodle as a tool of creating of the e-learning environment, the features of using this platform in teaching philosophy and analyze the relevant results of distance learning in quarantine 2020.

1.2 Analysis of Recent Research and Papers

The issue of the placing philosophical disciplines in the educational space is considered by scholars all over the world. The research paradigm is represented in (Crawford et al., 2005; Dewey, 1904; Halpern, 2014; Hintikka, 2007; Lakhuti, 2014; Quitadamo and Kurtz, 2007; Lipman, 2012), and others. The national tradition includes the publications (Karapetian, 2020; Kopotun et al., 2020; Terno, 2012). Dewey (Dewey,

1904) was one of the first educators who prioritized critical thinking in education. He believed that the main drawback of traditional education was its focus on refined knowledge, devoid of analytical processing. John Dewey outlined a new "reflexive" style of education, as reflection makes it possible for a student to perceive the object from different viewpoints. The philosopher notes that "knowledge" does not mean understanding; certain information does not guarantee that the opinion can get the right direction (Dewey, 1904). Hintikka (Hintikka, 2007) describes critical thinking as an opportunity to combine different perspectives, as a crucial resource, focused on the search for cognitive distortions. He thinks that to teach how to think and analyze is a huge challenge from education to philosophers (Lakhuti, 2014). The researcher substantiates the notion of Socratic epistemology as a special cognitive strategy, which has a dialogical form (Hintikka, 2007).

Standard educational programmes cannot achieve such progress in the development of cognitive skills, as the programmes, including the development of critical thinking. The author of an educational programme focused on reflective thinking Lipman (Lipman, 2012) admits that teaching thinking skills is different from the ordinary acquisition of academic knowledge. He substantiates the idea of higher order thinking, which synthesizes creative, moral, ethical and critical thinking. Lipman (Lipman, 2012) considers the ways of thinking as necessary modes of reflective educational practice. Lipman's approach was developed by Sanchez-Ruiz et al. (Sanchez-Ruiz et al., 2015), Reid and Anderson (Reid and Anderson, 2012) and others. Therefore, the reflexive paradigm highlights reflective and dialogic strategies as a development of personal autonomy embedded in a special space of mutual open-mindedness for joint exploration and discovery.

The use of the potential of philosophy in the development of critical thinking and other important competences is complicated due to several reasons. Firstly, the place of philosophy in a number of general educational courses is uncertain. Secondly, it is complicated to transfer the content of philosophical disciplines to e-learning platforms.

The practical implementation of distance learning is based on one of the most promising online learning platforms, which is actively implemented in the educational process and facilitates its modernization – Moodle. In the current educational discourse, the potential of using e-learning platforms is considered in various aspects (Astafieva et al., 2020). Petrenko (Petrenko, 2017), Pienkin and Yatsenko (Pienkin and Yatsenko, 2014) consider Moodle as an important component of the provision of distance education and blended learning. Zhelezniakova (Zhelezniakova, 2016) treat it as prerequisite for realization of the students' self-management capacity. Myshchyshen (Myshchyshen, 2011) considers Moodle as tools of information and communication support to the process of advanced training. Avdieiev (Avdieiev, 2015), Oproiu (Oproiu, 2015) draw attention to the fact that Moodle is a way to optimize the educational process in higher educational establishments. For Nedilko et al. (Nedilko et al., 2017) Moodle is a key aspect of quality of professional training of future specialists. Holotescu et al. (Holotescu et al., 2014) outline that e-learning platforms provide students' involvement in the global educational space and the development of lifelong learning skills. The use of e-learning platforms is also considered in the context of globalization, changes in the institutional status of the education system (Triakina et al., 2018). Biletska (Biletska, 2013), Horshkova (Horshkova, 2015), Mintii (Mintii, 2020), Semenets (Semenets, 2017) draw attention to the considerable practical experience of using Moodle in the process of teaching exact mathematical sciences and natural sciences. Dolynskyi (Dolynskyi, 2013), Akulenko (Akulenko, 2012), Shalatska et al. (Shalatska et al., 2020), Ustinova et al. (Ustinova et al., 2019) show that Moodle can be used by teaching social science and humanities.

1.3 Unsolved Aspects of the Problem

Unfortunately, there is a dangerous tendency in the national education to curtail the humanities, especially philosophy, ethics, aesthetics, cultural studies, etc. They are losing their positions, undermined by the tendencies of educational instrumentalism and vital pragmatism. The reasons of such situation are as follows: the relativization of the educational culture, the lack of definition of standards of quality of education, as well as rigidity, the firm rootedness of the "monopolized" post-Soviet educational tradition. After a few decades, philosophical subjects focused on Marxism lost their relevance, as they reproduced the structures of crowd psychology, the realized ideological function and function of identity formation. As a result, philosophy focused on Marxism created a false stereotype about its uncertainty or even its uselessness. Thus, a hidden paradox has emerged: the minimization of the humanities in education contradicts current educational strategies, outlined in the Law on Education.

Among the educational competences defined by the Law on Education, there are a number of extracurricular competences, which, in our opinion, provide for an in-depth mastery of a philosophical resource. According to the Law on Education, "common for all competences are the following skills: reading with understanding, a skill to express one's opinion orally and in writing, critical and systemic thinking, ability to logically justify one's position, creativity, leadership, ability to manage emotions in a constructive way, assess risks, make decisions, solve problems, ability to cooperate with other people" (Verkhovna Rada of Ukraine, 2017). Thorough analysis of the subject field, included in the scenario of achieving the stated goal, implies a direct mastery of the information product of philosophical genesis. Instrumental competence, which means performing technical procedures and operations, ways of determining information adequacy, criteria for trust in an information source, etc., is also particularly relevant.

Therefore, the main unsolved aspect of the problem is the question of whether the information, purified from philosophy, is sufficiently efficient in competitiveness of education if it is considered as a complex product, formed by long-term research selection by historical trial and error and as the result of successful, balanced, and projected educational programmes, focused on education and society, theory and practice. The implementation of electronic support in the teaching of philosophy is also important. However, the specific nature of philosophy as a subject should be taken into consideration. Using e-learning platforms is a definite challenge of the modern times, so the educators need to respond to it adequately.

Nevertheless, the following question arises: how and to what extent can we trust e-learning, in training philosophy and other humanities?

Instrumental and information competence becomes more topical. We may define it as the implementation of technical procedures and operations; the ways to determine information adequacy, criteria of its quality and trust in the source of information; the independence of information processing and reproduction based on academic integrity.

The previous research did not focus on the analysis of the complex specific character of modern education, its socio-ethical orientation, unapparent but important problem areas of distance learning, the research of the causes and factors of their elimination. These highlight a broader horizon of research. The main unresolved aspects of the problem are the following issues: whether learning management, cleansed of philosophy, is effective enough to provide competitive education as a complex social product; whether distance education can be considered as a universal learning tool that gives a sustainable result; whether distance education has the opposite effects and drawbacks arising due to the "dissolution" of participants of the educational process, who are in a "closed" e-learning environment. Thus, the objective of the paper is to reveal the peculiarities of electronic support of teaching philosophy, highlighting its subject specificity on the basis of methodically substantiated forms of test control.

2 THEORETICAL BASIS OF THE RESEARCH

As Shunevich (Shunevich, 2011) emphasized the formation of the theoretical framework of distance learning dates back to the 60s of the 20-th century. Shunevich (Shunevich, 2011) follows the classic of distance education Keegan (Keegan, 1980) and notes that the prolonged absence of theory has weakened distance learning. In the article "Comparative Analysis of Early Foreign Theories of Distance Learning", he describes the autonomy of the student in the educational process, emphasizes the fundamental difference between classical and distance learning (Shunevich, 2011). What is the essence of distance learning? The e-learning course is an artificial, dialogical opportunity for learning, in which the bridge between the student and the institution is an artificial signal carrier (Shunevich, 2011, p. 106). That is why, in our opinion, the e-learning platform should contain the parameters inherent in the process of natural learning with its flexible, multidimensional potential: forms, methods, tools, technologies, etc.

If philosophy is considered as a source of critical thinking, the method of its formation appears as a combination of different models of learning. It is clear that "rigid models" are typically suitable for individual tasks, while "soft models" dominate when there are atypical problematic situations with uncertainty potential. Such models play a special role in the process of personality formation. "The development of critical thinking is just such a task that can be solved with the help of a soft learning model", says Terno (Terno, 2012, p. 18). Methods of the critical thinking development require a set of conditions that include problematic situations, knowledge of critical thinking strategies, creating choice situations, making a dialogue, giving students' opinions in writing, the right to correct mistakes, etc. This system of learning implies its openness, plasticity, the presence of variations and feedback.

Individual-oriented project methods and dialogue play a special role, as they are focused on reconstructing the educational participants' individual experience. The methodology is based on the following principles: identifying and denying assumptions, verifying accuracy of facts and logical consistency, examining context and exploring alternatives (Terno, 2012, p. 18). In our opinion, this is the way in which the monologic "banking" or fixed teaching is reoriented to qualitatively developing innovative model.

Such a guideline was taken into account by the community of lecturers of the Philosophy Department in Kryvyi Rih State Pedagogical University in the process of teaching the course "Philosophy" with its positive consequences. Firstly, the philosophical resource was preserved as a source of formation of different types, styles of thinking, a methodological platform for learning the variety of the best examples of world philosophical culture. Secondly, the structure of the course, the logic of its presentation, demonstrated the effective implementation of a number of tasks of informative and constructive content, as it successfully combined the traditional informative or lecture-seminar system of education and the modern pedagogical approaches, which necessarily include person-oriented techniques. And fourthly, we would like to draw attention to the advantages and problems caused by using e-learning management systems in general and, in particular, by using Moodle, taking in consideration the global challenges of the COVID-19 pandemic.

Thus, there was a need to combine the critical resource of philosophy and the tools, provided by the e-learning environment. Obviously, such a combination could not have been a perfunctory transfer of the course to an online learning platform. However, it also requires both the peculiarities of the course and the specifics of the chosen platform. We used Moodle as such e-learning platform.

In our opinion, we should consider the particularities of using Moodle, taking into account the global challenges, tasks and problems that cause the reform of the education system in Ukraine. Moreover, it is necessary to pay attention to features of use of the platform in comparison with similar systems. Thirdly, it is necessary to demonstrate the expediency of appealing to Moodle, in the context of teaching the social sciences and humanities, especially philosophy.

As for the first aspect, we should admit that the implementation of Moodle is increasingly correlated with the prospect of implementing the principles of blended and distance learning, taking into account that the latter is a relatively new phenomenon in the educational space of Ukraine (Bondarenko et al., 2018). Petrenko (Petrenko, 2017) says: "The use of modern information and communication, electronic technologies in combination with pedagogical experience will allow to raise higher education in Ukraine to a higher level" (Petrenko, 2017, p. 140). This problem is also considered in the context of globalization, changes in the institutional status of the education system and the integration of the national education system into the European educational space (Petrenko, 2017, p. 116). In response to these challenges, the scholars draw attention to the following benefits of distance learning: the ability to save considerable amount of time while displaying significant amounts of information; focusing on the specific achievements of each student; ensuring the relative independence of the process of communication between the student and the teacher from the place and time, organization of control and planning of students' independent work in the conditions of reduction of class hours and transition to the credit-modular system, etc. (Lavrentieva et al., 2019, p. 102), (Zhelezniakova, 2016, p. 34). In general, these characteristics have economic, operational, informational and pedagogical dimensions (Myshchyshen, 2011, p. 98). Unlike distance learning that requires using ICT, blended learning presupposes a combination of different forms of activities (traditional, distance, electronic, etc.), at the same time it takes advantage of distance learning and eliminates its disadvantages (Petrenko, 2017, p. 141). An important tendency of recent years is the increasing level of integration of distance and traditional learning (Petrenko, 2017, p. 6).

As for the second aspect, we should mention that there are several groups of e-learning organization software: copyright software, learning management systems, content management systems, and educational content management systems (Pienkin and Yatsenko, 2014, p. 105). Among these tools, one of the most suitable for higher education institutions is the open source distance learning platforms, to which Moodle belongs (in general, there are a great number of such systems: ATutor, Claroline, Dokeos, Sakai, Prometheus, etc.) (Pienkin and Yatsenko, 2014, p. 106). A considerable number of scholars think that Moodle has certain advantages over other similar systems. The evidence is the considerable number of users who have chosen this system (about 90 million people (Petrenko, 2017, p. 140)), as well as the fact that it is used by educational institutions in more than 100 countries (Pienkin and Yatsenko, 2014, p. 106), demonstrating positive statistics of students' involvement (Oproiu, 2015, p. 428–430). The basis for the functioning of this system is based on the principles of social constructivism, according to which, the teacher is regarded as an assistant and mentor; training is carried out in activity; self-presentation and self-realization of students are provided; the learning environment is flexible, able to adapt to specific needs; the student can observe and respond to the activity of participants in the educational process (Teplytskyi et al., 2015). Accordingly, Moodle allows to organize distance learning in such a way that it meets the today's didactic requirements: regularity, systematic character, objectivity of control, individuality, economic efficiency, that is, it is fully capable of completing the tasks assigned to it (Avdieiev, 2015, p. 7).

Other advantages include: openness of the system, ability to adapt to specific tasks and types of activities; providing ample opportunities for communication and data exchange; the availability of a flexible evaluation system and opportunities for statistical analysis of performance; versatility and simplicity in using (Pienkin and Yatsenko, 2014, p. 106). An important argument in favour of Moodle is that as an open source system, it can be freely distributed, applied and modified (Pienkin and Yatsenko, 2014, p. 141).

Moodle is quite capable of providing the distance learning functions assigned to it, but it should be admitted that the use of a virtual learning environment has its peculiarities when it supports training courses in philosophical disciplines.

(1) *The complication of parameterization of learning outcomes*. This is due to the fact that all philosophical disciplines and, first of all, philosophy involve the teaching of thinking, and not just memorizing the biographies of a number of philosophers and difficult obscure terms. Obviously, this peculiarity is inherent in other courses, but the main difference is that the results of teaching philosophy are very difficult to calculate and quantify. This problem is typical, in general, for determining the level of competence formation, which does not reduce to specific knowledge, abilities and skills. We have discussed above the competences, which include, inter alia, environmental competence and information and communication competence, lifelong learning, civic and social competences related to the ideas of democracy, justice, equality, human rights, well-being and a healthy lifestyle, with an awareness of equal rights and opportunities; cultural competence. For this type of competence there is a problem of verification, parameterization, quantification, the solution of which would make it possible to simply revision of the level of their formation by tools of e-learning, where testing is particularly convenient and widespread.

(2) *The plurality of approaches*. The second problem is related to the specificity of philosophy, namely its pluralistic nature. Philosophy cannot be represented as a single holistic entity, the conventional result of a study of the existing philosophic community. Philosophy is a constant development of thought, which consists in asking questions, finding answers and constantly rethinking them. Thus, any reference or educational material in philosophy bears a significant imprint of the philosophical position of its author, which cannot be considered universally acceptable to all participants in philosophical discourse.

(3) *Communicative nature of philosophy*. There was an experiment when the android Bina48 gave a lecture on philosophy (Palmer, 2018). Its results show the achievements of robotics, but they do not mean a breakthrough in the teaching of philosophy. The main results of the teaching of philosophy are formed in the course of communication; they are argumentative and critical skills, values and socio-cultural competences.

For the use of e-learning courses is an up-to-date challenge that can greatly enhance students' cognitive activity through interesting activities, the philosophy teacher must find ways to integrate these activities into the learning process and use them in a way that does not deteriorate, but rather improve the quality of philosophy teaching. Obviously, it is simply impossible to fully implement a philosophy course on an e-learning platform without communicating with a teacher. It is not only about teacher's support in forums, chats, ongoing consultations and other forms of feedback, but it is also about full-fledged group seminars, involving pluralism of thoughts, discussions, and critical, philosophic reasoning in real-time.

3 RESULTS OF THE RESEARCH

In teaching philosophy, not all activities are reduced to face-to-face communication. The student has to develop skills of individual work, be able to work with primary sources, to carry out relations and systematization, to draw conclusions, to reason the opinion and to express it and so on. Thus, in the process of philosophy teaching, it makes sense to use e-learning courses as a support of full-time study, which allows to cover other activities of the student and to evaluate his or her individual work. Let us consider some of the techniques of using a Moodle-based e-learning course and their peculiarities in philosophy teaching, using the Moodle controlling tools in the philosophy course.

3.1 Test Control in the Flipped Classroom Model

Firstly, the thing that makes Moodle convenient is to provide theoretical material. This approach makes it possible to use the flipped classroom model when students are introduced to the lecture material before the lecture begins. Then, the lecture itself is based on explaining the most interesting points of the topic, discussing problematic and incomprehensible parts of the material.

It is advisable to combine the flipped classroom model with the simplest test to check whether the students have read the material to the lecture. Test tasks most often involve the literal reproduction of text and they perform two functions: checking for content understanding and activating memorization.

We should admit that the test assessment of the quality of the philosophy study is quite complicated and, when provided formally, it usually has a negative result. Firstly, ordinary tests are mainly focused on checking the memorization of certain characteristics, terms and names, which is quite possible without understanding the essence of the philosophical concept. Secondly, tests without any material, given in advance, provide students with a choice of a textbook or other reference sources. In the case of philosophy, it cannot be guaranteed that the opinion of the author of the test coincides with the way the relevant material is presented in the textbook chosen by the student. Thus, it is advisable to limit the use of simple verification tests as a control measure in the virtual accompaniment of philosophy training to the following parameters: (1) tests can only serve as a tool of the simplest control of familiarization with the material before the lecture; (2) tests should be directly bound to, and limited to, the material provided.

It is necessary to mention some technical points. Moodle allows you to create various types of tests. For this purpose, it is quite convenient to use several test types: multiple choice tests, tasks with short answer, matching tasks, built-in answers, gap texts, true or false statements. The most problematic types of tasks are multiple choice tests and gap texts, where a student has to fill in the missing words. In Moodle multiple choice tests are implemented very well, if you do not take into account the following feature: if the student selects all the answers, he or she will be assessed as having chosen all the right answers. Therefore, while creating the test, it is advisable to use the penalty for incorrect answers, which is realized by negative indicators.

Missed word assignments or the gap texts differ from short answers in that regular "*" expressions to substitute any character sequence cannot be used. Missing words should be filled in, so there is a serious spelling problem. If we do not consider the cases of the students' illiteracy or carelessness, we deal with the instability of Ukrainian-speaking philosophical terminology and the lack of a stable tradition of Ukrainian transliteration of the philosophers' names. For example, "Leibniz" can be spelled in Ukrainian as 'Лейбніц' – 'Лейбниц' – 'Лейбніць' – 'Ляйбниць' – 'Ляйбніц' and etc. There are several ways out of the situation. For example, it is possible to provide students with accurate spelling, to familiarize them with the terms to be used in the tests, and to provide clear instructions for completing this type of assignment.

3.2 Test Control of Independent (Out-of-Class) Learning

The university course in philosophy provides much of the material that the student studies out of the classroom. It is necessary to state that making notes and writing assignments are irreversibly out-of-date, but this should not be considered as a negative trend. Rewriting and reproduction is rapidly inferior to speculating and evaluation, which should be reflected as a change in teaching methods, especially in philosophical courses that have a world-view forming task. Independent study in a philosophy course means that the student works on certain themes for which the student has been provided with the relevant list of references. However, no one can guarantee that the student will not use Google search engine as the primary source of answers instead of reading recommended textbooks and sources. In such situation, one can find some positive aspects, as independent work involves familiarity with fairly standard concepts, definitions and personalities. Thus, doing simple tests for choosing names, book titles, philosophical directions will not be superfluous, and it will allow the out-of-class study with the online learning environment should also include tasks that do not provide obvious answers that pop up in the first search engine rows. So, it is advisable to develop tasks that help the student to master the material submitted for self-study. It is appropriate give the student a task to analyze the text where the student is offered to choose a statement that most fully reflects the main idea of the text, or a statement that contradicts the text, a statement that may or may not a conclusion.

The skill to work with primary sources, analyze them and correlate with the theoretical material described in the textbook is an important type of students' activity while studying philosophy. The primary sources are often discussed at the seminar, but this kind of work can be successfully implemented through the online support of the Moodle training course. In addition to widespread multiple-choice tasks and built-in answers, it is appropriate to use gap texts and true or false statements. Moreover, it is necessary to focus not on the literal reproduction of the text of the primary source, but on realizing the author's opinion and on correlating it with the philosophical direction or tradition to which the author of the text belongs. The re-writing tasks showed good results in "true or false statements", when the opinion presented in the source text is formulated in other words.

The specificity of test verification of out-of-class study is the need to set a deadline clearly. This is due to the fact that most of these tasks are woven into the canvas of the classroom material and their untimely fulfillment breaks the logic of teaching. On the other hand, the student should understand that out-of-class study is as chronologically regulated as activities in the classroom, which are carried out on schedule. The method of self-study is not regulated. It is focused on checking the results; thus the student develops skills of self-study, self-control and planning.

3.3 Test Implementation of Interim Thematic Control

The possibility to make full use of test tasks for interim control is also limited. Firstly, it does not justify setting a high score for these types of control, so it stimulates some manifestations of students' plagiarism, because it exists in a form of distance learning. Secondly, thematic control does not imply the availability of ready-made material, as in the case of preparation for an "flipped classroom" or an activity for checking understanding of primary sources. Thirdly, thematic control should be designed not only to check what students have memorized, but also to presuppose tasks that require speculation and reasoning. Thus, it is appropriate to use such tasks as matching, multiple choice tests, but with a slightly more complicated formulations. The challenges of finding a mismatch, finding an error, or finding the wrong answer are considered to be fruitful. The task of matching statements with authors has also shown good results as well as the tasks for chronological ordering. In addition to testing knowledge, the matching tasks also have a cognitive load: it is convenient to offer students a number of characteristics of philosophical directions or doctrines, which are usually opposed, in order to relate them to these areas (here it is appropriate to create the task in such a way that the characteristics are distributed evenly and not more than three parameters, optimally two). It is appropriate to offer students assignments for reasons that involve establishing a pattern, continuing a logical chain, choosing the causes or effects of a particular position.

We should draw attention to the task of drawing conclusions in which students are asked to select all the correct conclusions (or one) from the text proposed. In the simpler version, it is a reformulation of the thought, in a more complex one, the logical or substantive consequences generated by the idea demonstrated in the text. Test for matching is convenient to use as an extension of the test for true or false statements, because it allows you to evaluate a number of statements at once by correlating them with the choice of true/false.

The result of thematic control in this form is not only the score expressed in points, but also a certain broadening of the student's horizons. Obviously, in the development of in-class and out-of-class activities, the student does not focus on reading the works of the philosophers mentioned above, but focuses primarily on short theoretical information that can provide a clear answer to the questions of the seminar or the assignment for out-of-class study. Philosophy does not provide such answers. The teaching of philosophy involves the formation of the skills of contextual, discursive analysis, aimed at clarifying the course of reasoning of a particular philosopher, which leads him to certain conclusions. The mentioned test organization achieves at least two goals: firstly, it familiarizes students with the aphorisms and important quotations of the classics of philosophy, shows their depth, and secondly it develops the skills of philosophical analysis and intensifies educational interest. An indirect, but pleasant, consequence is that students remember the names of philosophers and basic philosophical terms.

4 RAPID APPROBATION OF DISTANCE LEARNING PHILOSOPHY

One of the main challenges for the education system worldwide has been the COVID-19 pandemic. The pandemic, as well as the severe restrictions imposed by governments of different countries to subdue the rapid outbreak of the disease, has affected the functioning of the social, economic, and political spheres of society and has significantly transformed all components of the learning process.

A key component of these changes is the active introduction of distance learning technologies at different levels from radio, television, and text messaging to full-fledged online learning (World Bank, 2020). As a rule, the leading role in this process was given to learning with the support of recent information and electronic technologies, the use of multimedia and e-learning. Such learning is known to involve two approaches: (1) asynchronous learning via the media, e-mail, discussion forums, where students and teachers do not have to be online together; (2) synchronous learning through video conferencing and live chat, allowing students and teachers to feel directly involved in the learning process rather than isolated from it (Lisnani et al., 2020). The responses to the decisions to control the risks and how to minimize their impact on the students by implementing all components of e-learning are as follows: using new educational technologies such as Learning Management Systems (LMS) of Moodle, and Blackboard for providing communication, sharing course content, exchanging lecture notes, slides, and other materials, controlling knowledge, and using Zoom and similar software products to schedule, stream, or record classes is a response to risk control decisions and the way to minimize the impact of those risks on students by implementing all components of e-learning (Hamaniuk et al., 2020).

Simultaneously, such overall, albeit forced, transition to distance learning requires not only the justification and implementation of the necessary changes in the shape and content of the education process but also an assessment of its current and potential consequences. However, the practical experience of the rapid transition to distance learning allows us to identify a number of not only positive but also negative aspects. Thus, in a positive sense, the benefits of the transition to e-learning are revealed in several directions.

(1) The general dimension include the active access to online resources to find the necessary information and materials, implementation of the function of recording lectures, meetings, benefits for personal growth and development (increasing computer literacy), increasing the use of available resources (Moodle and other platforms), updating technologies for the university.

(2) The pedagogical aspect presupposes that students and faculty could join the latest technologies and teaching tools, master the technologies of blended learning, and receive the opportunity to work remotely (Oyedotun, 2020, p. 2). It is also emphasized that the use of LMS in the education process helps to facilitate e-learning, as it allows access to learning without time or place restrictions, which is essential in the context of social isolation caused by the pandemic (Raza et al., 2021).

The negative aspects can be characterized as follows.

(1) Limited material and technical base, lack of necessary resources, equipment, Internet access (which questions the possibility of providing a full-fledged e-learning mode, while the offline mode is insufficient), lack of permanent power supply in some countries.

(2) Lack of sufficient qualifications, prior training and practical experience for both students and faculty.

(3) Problems with ensuring high-quality teaching due to limited technical capabilities reduced students' interest in work and lack of teacher-student engagement.

(4) Limited opportunities for monitoring knowledge and student malpractices.

(5) Factors of psychological and social pressure in connection with the pandemic, etc (Oyedotun, 2020, p. 2).

This list of risks can be continued if we take into account the experience of implementing distance learning at Kryvyi Rih State Pedagogical University. Firstly, there is the lack of a single e-learning platform clearly defined at the state level. Secondly, methodological support has been developed insufficiently. Thirdly, there are significant technical risks associated with the insufficient capacity of the existing material and technical base, etc.

As the global studies with the sample of 30,383 students from 62 countries show that most students appreciate the support of the faculty and communication with the university community, but the lack of computer skills and the sense of increasing workload have not allowed them to achieve higher learning results in new conditions (Aristovnik et al., 2020).

These problems concern not only the introduction of distance learning in a particular country. They arise due to the limited nature of the technology itself, the reassessment of its ability to fully achieve its objectives, to respond to other global challenges that are not directly related to the COVID-19 pandemic. It is obvious that these problems are also connected to the specifics of the rapid and forced transition to distance learning (although, of course, economic, social or political factors can significantly reduce or, conversely, increase their acuteness).

Simultaneously, we should also pay attention to the peculiarities of the social or mental environment, the way of providing education in a particular educational institution, the features of the course (including the cycle of philosophical disciplines), the possibility of their implementation by distance learning. As demonstrated by the analysis of changes in higher education in response to COVID-19 in 20 countries, the feedback from higher education providers could vary considerably and include both social isolation strategies and curriculum redevelopment for the transition to online learning (Crawford et al., 2020).

We will try to assess the consequences of the rapid transition to distance learning under quarantine restrictions, taking into account the specifics of the organization of education and the results of the final and current performance of the students at Kryvyi Rih State Pedagogical University (Ukraine).

The purpose of our analysis is the statistical generalization of the results of the current and final success of the students studying the course of philosophy with a different share of e-learning support. The analysis was carried out in the framework of teaching the course of philosophy in the second year of studying at Kryvyi Rih State Pedagogical University. The course of philosophy is taught for one year, so it lasts two terms. The final control is carried out in the form of an exam; the intermediate control is carried out only in the form of the sum of points received for the first term. The course provides the following distribution of hours by the types of activities: 34 hours of lectures, 34 hours of seminars, and 56 hours of self-study.

Traditionally, the course is taught entirely in the classroom, and Moodle is usually used to control the progress of the students' mastering the themes for self-study, to provide references and additional materials, and to support the work of part-time students. Since March 2020, educational institutions have been to significantly expand the use of learning management systems and online platforms. For the course of philosophy, such systems were mainly Moodle and Zoom. Thus, with the implementation of e-learning, a big share of the classroom material was presented in Moodle: the texts of the lectures, materials to prepare for seminars, primary sources with the tests to them to assess how the students have mastered the material. Besides, the teachers continued to hold classes according to schedule, but with the help of Zoom.

It is obvious that the organization of the learning process was not immediate; the adaptation to the new learning environment took place until about the end of April. It is easy to track, considering students' speed of scoring. To do this, we can compare the increase in the ratio of the total number of points in each seminar of the second term to the number of students in the group that did not have an experience of e-learning and the group that experienced distance learning in the second term (figure 1).

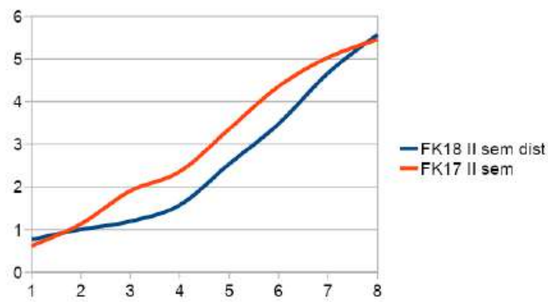

Figure 1: Speed of scoring in the second semester 2020.

For comparison, we used the data of the average student group of the Faculty of Natural Sciences (FK-18), which did not show a sharp decline in attendance due to the transition to distance learning, and the data from the previous year of the group of the relevant specialty (FK-17), which studied entirely in the classroom (the lecturer is the same in both cases).

The OY-axis on the figure 1 shows the scale of an average increase of points per n students of the group (the sum of points for the current t and previous themes divided by the number of n students in the group), themes (t) from 1 to 8 are plotted on the OX-axis. For clarity, the set of points is shown by a solid line.

The comparison of the speed of scoring shows a significant difference in the students' activity in the first month and a half of e-learning (themes 2-4 along the OX-axis). However, later the situation improved due to the fact that students adapted to the conditions and began to complete tasks. Thus, the average number of points gained during the term, by the end of the term was almost equal to the previous year, i.e. the students reached the standard.

Since autumn 2020, the learning of philosophy has been also continuing similarly as e-learning, but due to the fact that students have already been morally and technically prepared for that, there is no corresponding "failure". This can be seen from the comparison of the speed of scoring for the first term by groups FK-19 and FK-18, FK-17 (figure 2). Only the first group out of these three mastered the course of philosophy with extended distance learning support under quarantine in the first term, while in the first term, the rest two groups studied the corresponding course fully in the classroom.

Today, the speed of scoring in the classroom and online does not differ significantly.

In general, the results of the retrospective analysis of the rapid distance learning implementation can be divided into two groups. Firstly, these are subjective

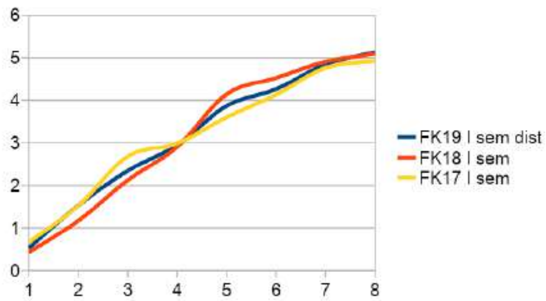

Figure 2: Speed of scoring in the first semester 2021.

impressions, and secondly, they are certain statistical generalizations.

Let us start with subjective impressions. We will not talk about the impressions of the organization of teaching during the quarantine and the efforts required for that. First of all, subjective impressions are about the student performance and quality of learning as well as the students' general attitude to study. Subjectively, the introduction of learning management system for studying philosophy has an interesting effect: the number of students with average points decreases significantly, while the number of students receiving a high score or a low score increases accordingly. Thus, students with good performance begin to study even better, but bad students – even worse.

This impression is illustrated by comparing the results of the exam session by groups of the Faculty of Foreign Languages (figure 3). For comparison, we have chosen all student groups of the admission year 2017–2018 (111 people) who took the philosophy exam in June 2019 and all student groups of the admission year 2018–2019 (70 people) who took the exam in June 2020. The first sample shows the results of the philosophy exam (2019) in groups where the students did not study online and the second one illustrates the results of the same exam (2020) in groups where the students studied philosophy online in the second term and where they had to pass the exam the online. We have considered only the results of the first attempt to pass the exam, and the grades for the resit of the exam are not taken into account.

Percentages are plotted on the OY-axis, and corresponding letter grades are on the-OX axis. It is clear that the percentage of letter grades A, B, C (excellent and good) has increased, but also the percentage of letter grades Fx and F (unsatisfactory) has increased. Simultaneously, there was a corresponding decrease in the percentage of letter grades D and E (satisfactory).

The students, who received a higher-than-expected grade, explain this fact as follows: they received constant access to learning materials, the opportunity to complete additional activities online, and the ability to score points online for classes they could not attend. Thus, as a rule, students who aspire for a good grade are offered to work with primary sources as additional tasks. This activity means that the lecturer conducts an extra colloquium with students to determine the level of text understanding. During e-learning, the assessment of the primary sources was accomplished using tests. Students noted that this is a convenient way of assessment because the questions fully correspond to the text of the primary source, so after reading the text, one can successfully pass the test. In addition, an unexpected motive for more active work for the students with good performance was the lack of access to grades and the level of preparation of other students. Thus, students noted that awareness of the poor level of preparation of other students usually affects negatively their motivation for better training. Moodle allows students to see only their own grades, so some of the students applying for the scholarship assumed that there were a significant number of students in their group who prepared better than them and, therefore, could get a higher score in the scholarship ranking. Thus, the number of the highest per cent grade (100) in 2019 was 15 out of 330 (4.5%), and in 2020 22 out of 297 (7.4%).

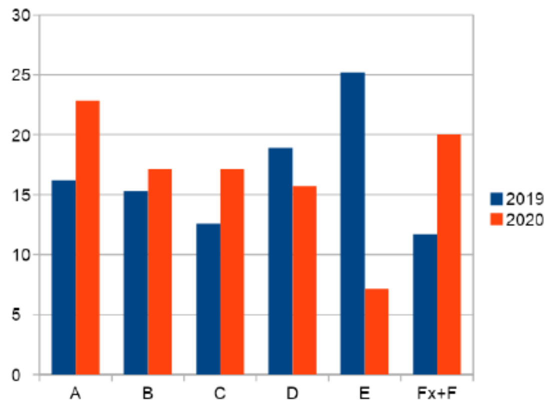

Figure 3: Comparing the results of the exam session by groups of the Faculty of Foreign Languages.

At the same time, the grades of the part of students who are usually classified as "weak E-graders" in many groups have shifted significantly towards Fx grade. It should be noted that the number of "lower" F (0-24 points) has increased significantly. From interviews with students, we have found out that when there is a low motivation to learn, personal contact with the lecturers serves as an additional means of control. The majority of students noted that they needed further explanations on how to use the learning management system and that they considered distance learning as a vacation, but hoped to make up for a lost time at the end of the term.

Let us consider statistical generalizations. The results of the analysis of a larger sample (table 1) including students from five faculties do not confirm the importance of “subjective impression”. For comparison, we used data from two samples: 2019 (the number of sample elements – 330) and 2020 (the number of sample elements – 297).

Table 1: General characteristics of the statistical sample.

	2019	2020
Number	330	297
Sum	20826	18999
Average	63.1091	63.9697
Mode	50	50
Median	62	63
Dispersion	388.6385	498.1376
Mean deviation	16.4436	18.0229
Asymmetry	0.1281	-0.2849

The column (2019) shows the results of the final control of groups that studied the course of philosophy only in the classroom. The corresponding share of e-learning platform involvement was insignificant; it was used mainly for controlling the studying of the themes required for self-study. These groups took the exam in June 2019.

The column (2020) shows the results of the final control of groups that studied the course of philosophy in the classroom in the first term, but in the second term, they were to transmit to e-learning. Thus, in the second term, the share of the learning management system increased significantly. These groups took the exam in June 2020.

The comparison of the characteristics of the two samples illustrates that the average, the mode and the median of the students’ grades in 2019 and 2020 are almost no different. There is a slight increase in dispersion and, consequently, in the mean deviation, but concerning percent grades (0-100), such values cannot be considered significant. There is a small but noticeable difference in the asymmetry of the two samples. Although the asymmetry of both samples is quite insignificant, in 2019, it was right-skewed, i.e. the values of the grades weighed slightly to the lesser side, while in 2020, the left-skewed asymmetry was obtained, i.e. overall grades increased slightly. We can talk about a slight increase in the extreme values of the sample, but, in general, it is not significant. It can be illustrated by analyzing of learning quality (figure 4).

Percentages are plotted on the-OY axis, the sum of excellent and good grades (A + B + C), satisfactory grades (D + E), unsatisfactory grades (Fx + F)

Figure 4: Learning quality.

are plotted on the OX-axis. In general, the learning quality in 2020 increased by 1%. Due to the “slippage” of E-students’ study results in 2020, learning success decreased by 2% (figure 5).

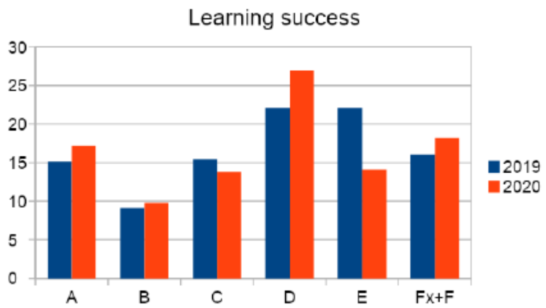

Figure 5: Learning success.

It is also interesting to track fluctuations in the percentage of letter grades. According to individual observations and surveys, it can be assumed that there was a “migration” of “lower” grades: C (good) and E (satisfactory). The percentage of these grades decreased since some students received a higher grade and some a lower one. Thus, the biggest fluctuation occurs in the percentage of the lower satisfactory grade E – 8%. The mode of grade D in 2019 was 65, and in 2020 it is 61. The mode of grade E itself has not changed (50), but the mode of grades Fx + F has increased (from 30 in 2019 to 45 in 2020) even with a simultaneous increase in the percentage of F. Therefore, we can assume that the grade E is partially “dissolved” in the neighbouring D and Fx grades, reducing the mode of the better grade and increasing the mode of the worse one.

Despite the lack of impressive differences and shocking results, we can say that the distance support of the philosophy course with the help of Moodle has successfully fulfilled its function of providing the learning process during the quarantine. Thus, taking into account the specifics of the subject and using the optimal means of organizing learning in Moodle, we can achieve results fully correlating with learning in the classroom. In our opinion, that indicates that the use of Moodle in teaching philosophy is quite beneficial.

5 CONCLUSIONS AND PROSPECTS OF FURTHER RESEARCH

Trends in modern education are linked, on the one hand, to the desire to develop cultural competences and, on the other, to take into account the informational influence, using its opportunities. The philosophical courses, especially philosophy, are directly meant for the formation of beliefs and convictions, values, systemic and scientific worldview. Therefore, the significant reduction or even the complete exclusion of philosophy from higher education in favour of majors jeopardizes the realization of the stated educational priorities. The creation an e-learning environment will help to simplify and universalize a significant number of types of activities dealt with memorizing information and providing control, so lectures have more time for other activities. First of all, these are activities directly related to communication, which is an integral part of the philosophy training. Moodle can be used as a tool of the online support of the philosophy course, but it is not possible to transfer a full amount of discipline into the virtual space, as this course has a considerable ideological load. This is due to the dialogic, discursive, communicative and pluralistic nature of philosophy. However, taking into account the peculiarities of the discipline, it is possible to provide not only the evaluative function of test control, but also to realize a number of educational functions: the updating of basic knowledge, memorization, activation of cognitive interest, the development of ability to reason and more simple, but not less important, – the skill to familiarize oneself with information.

We should note that the use of e-learning environment on the one hand imposes certain restrictions on the educators and creates a risk of “mechanical” passage of the course by the students. At the same time, it encourages the teacher to develop new and rethink existing forms of learning in order to fully implement them in e-learning support systems (Hamaniuk et al., 2020).

The peculiarities of the use of Moodle as a tool in the philosophy teaching can be extended to other courses, not just the humanities. They open the prospect of using test tools not only as a control but also as an effective learning tool. Moodle tools such as essays and seminars are promising to assess the level of idea formation, the ability to express and reason students’ own opinions, but they also have their own implementation specifics, which we will highlight in future research.

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Applied Technology of Fiction and Non-fiction Conceptual Presentation via ICT Tools: Pedagogical Function of Graphic Mimesis

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Keywords: Technology, Lyrical Protagonist, Emoji, Emoji Maker, Multimodality, Computer Being (CB), Graphic Mimesis, Text Mining.

Abstract: The article deals with the technology of structuring and visualizing fictional and real life empirical concepts with the help of emoji symbols in open source digital text mining platforms that not only activates students' thinking, but also develops creative attention, makes it possible to reproduce the meaning of poetry in a succinct way, develops comprehensive digital literacy. The application of this technology has yielded the significance of introducing emoji in the study and mastering of literature is absolutely logical: an emoji, phenomenologically, logically and eidologically installed in the digital continuum, is separated from the natural language provided by (ethno)logy, and is implicitly embedded into (cosmo)logy. The technology application object is the text of the twentieth century Cuban poet José Ángel Buesa. The choice of poetry was dictated by the appeal to the most important function of emoji – the expression of feelings, emotions, and mood. It has been discovered that sensuality can reconstructed with the help of this type of meta-linguistic digital continuum. It is noted that during the emoji design in the Emoji Maker program, due to the technical limitations of the platform, it is possible to phenomenologize one's own essential-empirical reconstruction of the lyrical image. Creating the image of the lyrical protagonist sign, it was sensible to apply knowledge in linguistics, philosophy of language, psychology, psycholinguistics, literary criticism. By constructing the sign, a special emphasis was placed on the facial emogram, which also plays an essential role in the transmission of a wide range of emotions, moods, feelings of the lyrical protagonist. Consequently, the Emoji Maker digital platform allowed to create a new model of digital presentation of fiction, especially considering the psychophysiological characteristics of the lyrical protagonist. Thus, the interpreting reader, using a specific digital toolkit – a visual iconic sign (smile) – reproduces the polylaterial metalinguistic multimodality of the sign meaning in fiction. The effectiveness of this approach is verified by the poly-functional emoji ousia, tested on texts of fiction. The experiment with the construction of signs and concepts in the Emoji Maker platform was supplemented by another experiment involving students in its visualization. The location specificity of the experimenters and respondents of the experiment is taken as the basis for generating a sign – the image of Borys Grinchenko as a patron of the Borys Grinchenko Kyiv University. Consequently, an individual approach to the visualization of corpus data was tested using the web application Voyant Tools, which works as an open source, providing text mining data. It is proved that with the support of reading and interpreting texts or corpus, digital analysis of the text becomes a significant linguistic addition to the generated sign. And the visual complement can be based both on a specific text (poetry by José Ángel Buesa) and on keywords / concepts (the image of Borys Grinchenko in the context of a specified location – at Borys Grinchenko Kyiv University).

1 INTRODUCTION

Problem statement. Emoji signs are specific Unicode-based ideograms. Nowadays emotions and impressions of the written and read text can be con-

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veyed in the form of punctiograms, pictograms and ideograms. Emoji is a multifunctional ideogram that not only saves one space in correspondence when communicating through social media, but also conveys shades of emotions, moods, feelings based on what one sees, hears, or reads. No wonder emoji in the modern world is considered a hieroglyph of the 21st century.

As modern literary criticism undergoes a process of depressurization, the allure of digital capabilities of the Emoji Maker platform as a metalinguistic phenomenon to the study of literary works will increase the interest of students of philology in works of fiction, developing creative thinking (Pidopryhora, 2019). The specificity of applying emoji to the analysis of a fictional text and, on a larger scale, to empirical experiences of concept construction by students in real life is to condense and synergize the result. This is primarily due to the fact that emoji modeling and conceptual visualization takes into account only the most basic and key senses. This avoids the recipient's own context when interpreting the text and concept and grasps the main point. That is why the transmission of the content of major genres (stories, novels, trilogies) is possible by modeling one or more emoji. All this also develops the ability and skill to create visual texts that will convey the full range of feelings from a read piece of fiction. This type of visual texts conveys the content of the reading as briefly as possible, activate memory, critical assessment, attention of students. It is through emoji that one can translate fiction, film, other fictional and non-fictional media, as well as real life experiences. In addition, the improvement and modernization of the structural and logical specifics of the visualization of the artistic image help to increase the efficiency of the image, which consists of the flexibility and clarity of the physiognomic interpretive series in the image. The latter, in turn, brings the visualized image closer to the original. However, this is a problematic field, because the visualization of the image with emoji is impossible without taking into account mental frames that structurally represent individual (stereotypical) factors of human consciousness and memory, depending on ethnic, national, and cultural systems. The latter, in turn, encodes in the human mind internal (psychology, picture of the world) and external (physiognomy) personality identifiers, which are explicated in psychology as mental frames. Taking into account all the above, there is a problem not only in the interpretation of a verbal text but also in the optical visualization of the text and/or its images.

The objective of the paper. Development and testing of information and communication technology application of presentation of different genres of fiction and contextualized educational concepts via the Emojidom Smiley, Emoji Maker (PlantPurple Sticker Apps, 2018) and Voyant Tools (https://voyant-tools.org/); approbation of the algorithm of visualization of literary text images on an abstract (non-artistic) image (the image of the patron of Borys Grinchenko Kyiv University) within the development of emotional intelligence of the student, expressed in the flexibility of mind with a creative approach to the visualization of ideas and images.

Information and communication technology (ICT), where technology is understood as a set of methods, tools and implementation by a person of a complex process by dividing it into a system of sequential interconnected procedures and operations that are performed more or less uniquely and aim at achieving high efficiency of a certain activity (Kommers et al., 2015), in our study emphasized the role of unified technologies, namely, software (Emoji Maker, Voyant Tools). This allowed students to create a model of visual interpretation of artistic (poetic) text during the experiment. With a limited set of tools in the program set, students rely on their own essential empirical experience and on a sensory typology that corresponds to three main types – visual, audio and kinesthetic (Franken, 2007). In addition to aforementioned, students, using the color scheme, rely on general information about the person's physiognomic characteristics (Franken, 2007), which allows them to accomplish the task: to model the features of the faces of lyric characters in Emoji Maker according to contextual events, feelings, phenomena.

Analysis of recent research and publications. According to Pidopryhora (Pidopryhora, 2019), "... the invasion of new technologies (computer, Internet) into the sphere of literature – changes the nature of authorship, the structure of text, the essence of reading and the form of interaction between the reader and the text, the level of communication interaction author – reader – text" (Pidopryhora, 2019). Thus, emoji literature technology enhances the ability of philological students to convey the content of literature in the most appropriate characters or symbols.

Emoji researchers are convinced that these characters have great hypertext potential. For example, there have been attempts to translate the text of Herman Melville's novel "Moby Dick" via the appropriate emoji, called "Emoji Dick" (Benenson, 2010).

Lebduska (Lebduska, 2014) concluded that emoji does not threaten the alphabetic literacy of the student, providing instead a means of creative graphic expression. This sentence is supported by the argument that in some cases emojis, on the contrary, help to explain the intentions or tone of the verbal text, but not without taking into account the cultural and contextual field. Therefore, the author of the article appeals to the conclusion of T. J. Mitchell: "In this replacing of text, emojis may be perceived as participating in the "protracted struggle" between the pictorial and the linguistic that T. J. Mitchell observed, "the relationship of subversion, in which language or imagery looks into its own heart and finds lurking there its opposite number" (Lebduska, 2014).

An emoji researcher Danesi (Danesi, 2016) also takes up the dichotomous position. The author offers a number of interesting examples of the use of optical signs, emphasizing the increasing interest in the technological visualization of verbal texts using emoji. However, Danesi (Danesi, 2016) questions the universality of the optical structure of emoji, which, in turn, also appeals to mental frames in sign generation.

Today, emoji is not only a linguistic tool, but also a psycho-physicalist one. By modeling this or that facial expression of an emoji, the author gives it the emotional touch that corresponds to the level of sensuality. The emoji face performs an informative function, that is, communicates to the interlocutor the emoji author's response to a text, which greatly diversifies written communication.

Consequently, by making sense of poetry with the help of a self-designed emoji corps in Emoji Maker platform, philological students have the opportunity to expand the range of emotions, moods and experiences that arise in the process of reading poetry and especially its interpretation. Emoji face expression is a student's creative approach to understanding the essence of prose and poetry. After all, all human feelings are expressed not so much in words as in facial expressions. So, we offer emoji modeling technique that reproduces the artistic meaning of poetry.

2 RESEARCH METHODOLOGY

The following methods were used to solve the established problems: empirical – in the course of conducting an experimental study of emoji modeling in class with students; applying a systematic approach to consider an object as a system model; functional approach – to determine the functions performed by the model; pedagogical modeling (Ostapenko, 2005) – for the study of pedagogical objects (phenomena) by means of modeling of conceptual, procedural, structural-content and conceptual characteristics and individual "sides" of the educational process within the defined socio-cultural space at the general educational level; aspect analysis of the artistic text – for the separation of stanzas and content clusters; deductive – for sign assembly.

3 RESEARCH RESULTS

Natural language in its ousia is that macrocosm that is reproduced in the continuum of the world of things (Plato, 1997). As we know, the efficacy of this subordination to a pragmatic world gives natural language the evolutionary status – capable of expansion, and most importantly capable of simplification. The latter, in turn, has an ontogenetic function of preserving and extending the human race: "We must simplify grammar until grammar has simplified us" (Redacción Centro Gabo, 2018). It concerns the codification of human consciousness through language, and more precisely, through its unilateral structure (*US*) and polylateral ousia (*PO*). We emphasize the term ousia, since the term has passed the stage of modification and in the Greek language the denotation of this concept is absent. In modern Greek, the term is interpreted to mean the essence and nature of a thing. However, the "Dictionary of Untranslatables: A Philosophical Lexicon" (Cassin et al., 2014) presents differences in understanding of concepts by different scholars and in different epochs. The dictionary emphasizes that the meaning of the word has undergone a radical transformation between Plato and Aristotle, since the former understood everything in the modern sense of "property" and in the philosophical sense of the essence of things, while the latter added other meanings, identifying ousia with ὑποκείμενον/theme (causes it to lable εἶδος through ousia sometimes, a type or feature, sometimes the unity of matter and eidos, and sometimes matter itself). Through the subsequent history of philosophy, the situation was increasingly complicated, since the Stoics regarded everything as an indeterminate substrate, thinkers of middle Platonism and Neo-Platonism returned to the meaning of "essence", and Christian Christology approximated υπόστασις with ousia giving the latter more enriched meanings, nonexistent in modern Greek (Cassin et al., 2014). It is because of differences in translations and interpretations that all modern Greek translators have decided to leave the word untranslatable, taking into account the entire range of interpretations available. The latter gives us the possibility to use the term "ousia" in the study.

It is worth noting that the unilateralism of the structure is not universal to all speakers, but is identical to the distinctive thinking (DT) of a person, which, in turn, is an explanatory factor for the evolution of language. Let us describe this process with the following formula:

$$\frac{US+DT}{PO},$$

where PO is a substantiated exponent, in fact, the material expression of a linguistic sign.

In the context of language simplification, the work of Wittgenstein (Wittgenstein, 2007) "Tractatus Logico-Philosophicus" plays a key role. According to the concept of the scholar, called "language game", which correlates, and at the same time contradicts, the role of natural language in the reflection of the world, it is believed that natural language is most capable of world reproduction, but the peculiarity of language games is that there are specific rules that each player can understand differently. However, this is precisely the reason for the multilateral character of the ousia of a sign. After all, we are already dealing with the arbitrariness of his understanding (Wundt, 1874).

The only field, where a sign synthesizes all its meanings, is exclusively a metalinguistic environment – one where any linguistic unit is reproduced as a linguistic-communicative (Bally, 1965; von Humboldt, 1999; de Saussure, 1971), and logical and philosophical essence (Frege, 1879; Peirce, 1994; Wittgenstein, 2007). Such a field is computer being (CB) – a complex, multidimensional sphere of synthesis of reality, human experience and activity, mediated by digital and information technologies (Kutyrev, 2001). The linguistic aspect of CB research is determined by objective historical and geopolitical prerequisites: cybernetization, globalization, informatization of world society (Lebduska, 2014, p. 1). It is in the continuum of CB, where the language game is the symbolic and semiotic foundation of Web 2.0 platform testing, that game rules acquire metal-linguistic characteristics and require special content analysis.

Essential-empirical analysis of computer being as a linguistic universal continuum uninstalls the following ethno-barriers: folk-mythological arsenal, cultural paradigms, socio-political discourses, etc. The key to this uninstallation is the phenomenon of "emoji" – "ideograms or emoticons used in emails and web pages" (Lexico, 2021). The digital emoji corps is a technogenetic mimesis of pictographic writing. The function of emoji, as pictography, is to identify the meaning, the content of which a priori eliminates its own invariance, transgressively appealing to the logical-eidological plane (Reformatskii, 2004). Emoji in CB is a universe, its visualization is exploited by the macrostructure of technogenesis, which is indicated by the internal unity of its components at the micro- and macro-levels and in the plane of the sign substrate (formal and semantic elements and structures) and the synthesis of features of ontological, cognitive and anthropological substance (Lebduska, 2014, p. 2).

Thus, the importance of implementing CB emoji in the study and interpretation of literature is absolutely natural: emoji, phenomenologically, logically and eidologically installed in the digital continuum, is separated from the natural language predicated by (ethno)logy, and implicitly embedded in (cosmo)logy. Understanding emoji is not subordinated to the nationality of the speakers. Another interpretation is that each speaker interprets the linguistic field in terms of its empirically-essential foundation, but this premise does not preclude the understanding of emoji.

Emphasizing the iconicity of the emoji corps, we appeal to the concept of modality and multimodality. Bally (Bally, 1965) noted that modality is the soul of the proposal; like thought, it is formed predominantly as a result of the active operation of the speaker who speaks. The scholar distinguished the main content (dictum) and its modal part (modus), which formulates emotions and intellect of reasoning regarding dictum. And therefore, modality is expressed in two types: objective and subjective. (Inter)synthesis of these types also involves multimodality as a way of constructing and reconstructing concepts and meanings with their integration into a metalinguistic semantic field, in which, in fact, the hypertext semiotic code is established. Thus, with emoji we get to a multilevel structure of language – from the phonetic level to the textual level.

Before proceeding to the empirical analysis of poetry modelling, let's define the algorithm by which, with the application of the Emoji Maker program, emoji is constructed taking into account formal and informative factors of a fictional text.

1. At the first stage, students are offered poetry for analysis. Emphasizing that poetry is imagery, and therefore its analysis must be accompanied by imaginative and critical thinking.
2. At the second stage, we propose to analyze the text using the Emoji Maker digital program, having outlined the purpose and tasks before. The program provides students with a limited list of options for creating emoji, and thus the students' creative and creative skills, as well as the essential empirical experience that will allow them to explain and substantiate the color choices of the emoji and its components, play a special role in the task.
3. At the third stage, we must emphasize to the students: emoji models should correlate with the

ACUÉRDATE DE MÍ	REMEMBER ME	НЕ ЗАБУВАЙ
I. Cuando vengan las sombras del olvido a borrar de mi alma el sentimiento, no dejes, por Dios, borrar el nido donde siempre durmió mi pensamiento.	I. When shadows of oblivion advance expunging feeling from my very soul, for God's sake don't erase the case where dwell the thoughts to you I owe.	I. Коли прибудуть тіні забуття, Щоб почуттів в душі спинити існування, Благаю Богом, збережи буття, В котрім завжди жило моє кохання.
II. Si sabes que mi amor jamás olvida que no puedo vivir lejos de ti dime que en el sendero de la vida alguna vez te acordarás de mí.	II. Should you so know my love fails not, that I can't live afar from thee, Do tell me, on thy earthly trot you will remember me.	II. Як знаєш, що любов моя нетлінна, Що жить без тебе – за бік узбереж, Скажи, що на путі життєво цінній Одного разу мене ти впом'янеш.
III. Cuando al pasar inclines la cabeza y yo no pueda recoger tu llanto, en esa soledad de la tristeza te acordarás de aquel que te amó tanto.	III. When you bow your head passing by, me unable to dampen your tears, in that loneliness gone awry You'll remember my love perseveres.	III. Коли в путі чоло огорне сум, І я не зможу сліз твоїх спинити, В цій одинокості печальних дум Упом'янеш того, хто вмів любити.
IV. No podrás olvidar que te he adorado con ciego y delirante frenesí y en las confusas sombras del pasado, luz de mis ojos, te acordarás de mí.	IV. You cannot forget. I've adored thee with blind and delirious frenzy In the shadows of past gone hazy, delight of my eyes, you'll recall me.	IV. Ти не забудеш мого боготворіння, Безумного й сліпого до безтями В прожитому, що заплелося тінню, Мене згадаєш за очей свічами
V. El tiempo corre con denso vuelo ya se va adelantando entre los dos no me olvides jamás. ¡Dame un recuerdo! y no me digas para siempre adiós.	V. Time flies with thick might, Far ahead separating us two, Don't forget me. Deliver a token! and don't fare me well anigh.	V. Час тяжко простягається по колу І вже випурхує між нас у це буття. Не забувай! Не забувай мене ніколи. Не говори мені «Прощай без вороття!»
(José Ángel Buesa)	(Translation by Rusudan K. Makhachashvili)	(Translation by Anna O. Bakhtina)

content of the poetry, as well as formally reflect the mood and feelings of both the lyrical hero and the reader.

We shall proceed with the example of the poetry of a twentieth century Cuban poet José Ángel Buesa. The selection of poetry in this case is to appeal to the most important function of emoji – the expression of feelings. In his lifetime, José Buesa acquired the status of "enamored poet", that is, a poet whose poetry is distinguished by sensuality in his own metaphor. Therefore, we believe that it is appropriate to reconstruct this sensibility with the help of the aforementioned metalinguistic digital continuum. We apply the Emoji Maker digital platform (PlantPurple Sticker Apps, 2018). The program has technical limitations, which, however, seal the phenomenology of the presentation. These limitations are specifically available repertoire of tools that cannot be traversed during image rendering. Emoji Maker contains the following skins: face shape, more shape, eye, eye brow, mouth, hair, sunglasses, hands, hats, others, background.

We shall further disclose the completion of the sample study task: to recreate the meaning of the following poem by Buesa (Buesa, 2020) using self-designed emoji in Emoji Maker tool (table 1).

The reconstruction of the poem should begin with its division. The poem contains of 20 lines, divided into 5 quatrains. We take each quatrain individually, so as a result we have to create 5 emoji characters. We reduce the compilation of the sign to deduction, that is, for each quatrain we define the universal qualities of emotion (UQE).

I. When shadows of oblivion advance,
expunging feeling from my very soul,
for God's sake don't erase the case
where dwell the thoughts
to you I owe.

Lyrical Hero = Love + Memory. So, we create the image of a character – a lyrical hero who pleads to be remembered be his love. UQE: anxiety, sadness, fear, hope. The main feature (hereinafter referred to as the "MF") is the PRAYER.

1. We take the yellow circle as the basis. Yellow in this case – as a symbol of hope, but at the same time – the sadness of separation (figure 1).
2. The choice of eyes is justified by the pleading expressed by the lyric hero. The main feature – mirrored dilated pupils, reminiscent of tears (figure 2).
3. The main expression of emotions rests in the eyebrows, because the quatrain expresses a plea. Therefore, the eyebrows rise to the central frontal part of the eye (figure 3).

Figure 1: Creation of the emoji sign #1.

Figure 2: Creation of the emoji sign #1.1.

Figure 3: Creation of the emoji sign #1.2.

4. The corners of his lips are slightly down, which also testifies to the sadness of the lyrical hero (figure 4).

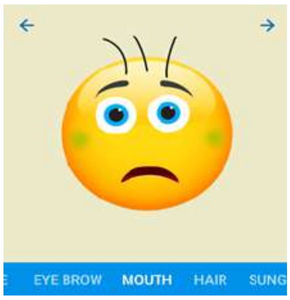

Figure 4: Creation of the emoji sign #1.3.

5. The choice of the lyrical hero's hairstyle correlates with his essence – romantic nature. Therefore, the hair is blond, not too short, disinfected (figure 5).

Figure 5: Creation of the emoji sign #1.4.

6. In this quatrain supplications can also be defined by gesture: palms are opened, the geometry of which involves the coverage of the object of love (figure 6).

Figure 6: Creation of the emoji sign #1.5.

7. In addition, pleading can be emphasized with conditional tears, which gives the lyrical character the desired effect.

II. Should you so know my love fails not,
that I can't live afar from thee,
Do tell me, on thy earthly trot
you will remember me

Lyrical Hero = love + memory + incorruption. MF – ETERNITY. For the sake of this quatrain, in order to avoid repetition of images, one can portray a potential fiancée of a lyrical hero who mentions love. UQE: thoughtfulness, memories.

1. Let us pay attention to the lips of the alleged girl: it ought to be a red, full mouth, closed, which will indicate the reflections of the heroine, her memories. The pupils of the eyes will look sideways and downwards, which will again indicate the girl's reflections (figure 7).
2. Hairstyle is also important because the length of hair, color, style correlates with the character of the woman. So, based on the limited selection offered by Emoji Maker, we choose medium length, black hair. With this choice, we visualize a girl as a young person, ages 23–25 (figure 8).

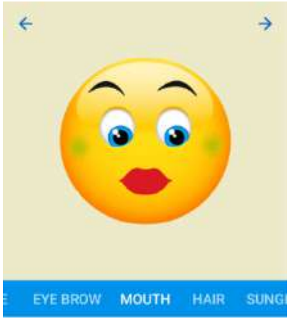

Figure 7: Creation of the emoji sign #2.

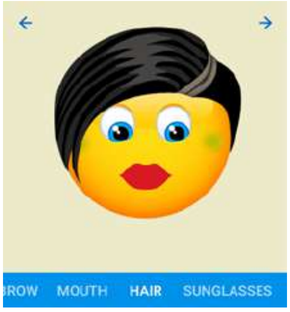

Figure 8: Creation of the emoji sign #2.1.

3. In digital age, communication cannot be imagined without gadgets. With that in mind, let's portray a girl with a mobile phone: so we can be interpretatively assumed that the girl's memories are symbolically stored on the device (photos, videos, etc.) – which is easier for students to relate to (figure 9).

Figure 9: Creation of the emoji sign #2.2.

4. We can complete the image with a universal denotation of love – a heart (figure 10).

III. When you bow your head passing by,
me unable to dampen your tears, in that loneliness gone awry
You'll remember my love perseveres.

Lyrical Hero = Love + Sadness + Memory + Thoughts. MF is loneliness. UQE: sadness, memories, longing, despair.

Figure 10: Creation of the emoji sign #2.3.

1. It is worth noting that in Spanish speaking cultures, green is the color of hope in love (Chesterton, 2007, p. 15), and therefore, an emoji experiment with a green smiley is advisable. Because the hope of memories rests on the subject addressed in the poem by the lyrical hero, so here we portray the girl (figure 11).

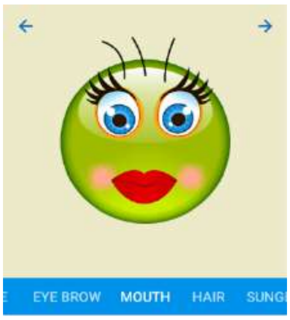

Figure 11: Creation of the emoji sign #3.

2. We leave the physiognomic characteristics the same as those in the second quatrain. And to visualize of the UQE we add the denotation of sorrow – tears (figure 12).

Figure 12: Creation of the emoji sign #3.1.

IV. You cannot forget. I've adored thee
with blind and delirious frenzy
In the shadows of past gone hazy,
delight of my eyes, you'll recall me.

Lyrical Hero = Love + Memory + Time. OR is a passion. UQE: madness, passion.

1. Universal characteristic of red color – love, passion; anger. Given the context of the quatrains, we construct a smiley face of red color, which will symbolize the love of the lyrical hero, his passionate feelings (figure 13).

Figure 13: Creation of the emoji sign #4.

2. The hairstyle of the lyrical hero remains unchanged, as in the previous image, symbolizing the romantic nature. Lips play a key role in this image. Let us portray them as half-open, which shows the interest of the lyric hero, his admiration for the woman (figure 14).

Figure 14: Creation of the emoji sign #4.1.

3. However, the most fundamental function of the UQE described in this quatrain is the attribute of love and romance. So let's depict the lyrical hero in heart-shaped glasses, a rose, and a brush that characterizes the hero as a dreamer, an artist who, in his own reminiscence, abstractly depicts the image of a beloved woman (figure 15).

V. Time flies with thick might,
Far ahead separating us two,
Don't forget me.
Deliver a token!
and don't fare me well
anigh.

Lyrical Hero = Love + Time + Inevitability +

Figure 15: Creation of the emoji sign #4.2.

Farewell + Memory. MF – timelessness. UQE: hope, memories, supplications, hopelessness.

1. The last quatrain demonstrates in the most detail the purpose of the lyrical hero as a kind of prayer to a woman: the feeling of not returning, the inevitability of time makes the hero appreciate his feelings. He also brings this up with a woman, pleading with her to remember his feelings as well. The poetic motif is that love will persevere as long as it is remembered. Let's finish the visualization of poetry in the blue color of the emoticon, where blue is the universal symbol of hope, the fulfillment of a memory dream in time (figure 16).

Figure 16: Creation of the emoji sign #5.

2. A plea not to say "Farewell!" we can depict through another universal sign – muted lips (figure 17).
3. We complete the digital reconstruction with symbolic attributes: the pager (obsolete technology) reproduces the semantic nature of the image of time, the equivalents of which are being-timelessness-eternity-Cosmos-Eidos (figure 18).

So, with the help of the Emoji Maker computer program, we introduce a visual reconstruction of J. Á. Buesa's poem "Remember Me". This approach simplifies the isolation of the fundamental factors underlying poetry. First, considering the person's physiology, we tried to single out meanings that suggest

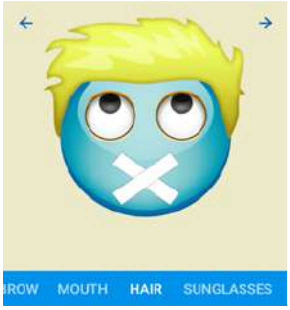

Figure 17: Creation of the emoji sign #5.1.

Figure 18: Creation of the emoji sign #5.2.

the presence of the following feelings: love, anxiety, sadness, fear, hope, memories, supplication, hopelessness. Visual affirmation of the senses contributes to a profound awareness of the fundamental concept of the poem – time, which can be correlated by the micro- and macro-cosmic elements of being (and in our case, computer being): being-timelessness-eternity-Cosmos-Eidos.

By recreating poetry through an ICT semiotic tool, students can potentially reproduce the meaning, imagery and content of the text only through the chain of emoji created (figure 19).

Applying the Emoji Maker multimedia program when analyzing a work of art (poetry) in the classroom, one should adhere to the following guidelines:

1. Before moving on to modeling emoji, it is necessary to outline the main idea of the text, because it depends on the further characteristics of poetry and its visualization.
2. Describe the lyrical hero, outline his role and function in the text. Describe his mood, feelings, emotions.
3. It is worth remembering that the reception of the reader can be validated only by the feeling and emotions of the lyrical hero, but not by the content of poetry.
4. Visualize the appearance of the lyrical hero without departing from the context of poetry. Imagine the emotions of the hero, hypothetically outlining

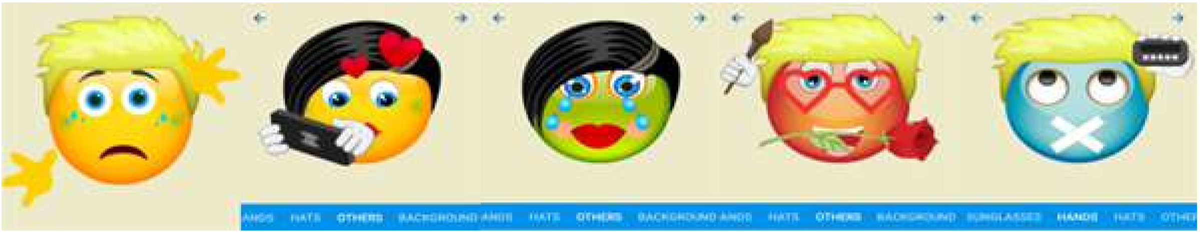

Figure 19: Projected emoji-visualization of J. Á. Buesa's poem "Remember me".

the physiognomistic characteristics relevant to the mood and feelings of the lyrical hero. You can now move to image modeling in Emoji Maker.

5. It should be noted that the choice of options in the program is limited, and therefore, their use should be qualitative and contextual.
6. Each option used must be defendable – only under this condition the correlation of ICT tools potential with the content of poetry can be traced.

Creating a multimodal picture of the world with emoji is possible not only in the context of fiction. The conceptual field of an optical sign, which transgresses its plane of content from a symbol to a full-fledged text, which the reader-interpreter immanently "adds" depending on the contextual boundaries, allows the emoji sign to be tested as a phenomenon. That is, one that is able to replace the letter with the image of the letter – with its opticality – while preserving the full meaning of what is said.

In order to confirm the above, the authorial team, together with students, conducted an experiment to design emoji. Students of Borys Grinchemko Kyiv University at a workshop "*MODERN DIGITAL TECHNOLOGIES OF LINGUISTIC DATA PROCESSING*" (coaches – R. Makhachashvili and A. Bakhtina), which was conducted as part of the Grinchenko Decade, joined the design experiment (utilizing the Emoji Maker tool) to construct the image of the patron of the university – Borys Grinchenko.

As in the case of fiction, the physiognomic and conceptual features of the creation of the sign were taken into account. Physiognomic features include facial features and recognizable highlights of the face, while conceptual features include the color turquoise (sea green), which is the customized corporate color of Borys Grinchenko Kyiv University (figure 20).

As can be seen, the use of physiognomic and conceptual characteristics (key features) allows to most accurately reproduce the image using the digital platform Emoji Maker, thus appealing to the digital optimization of the linguistic picture of the world. The rotation of the transgression of the linguistic picture

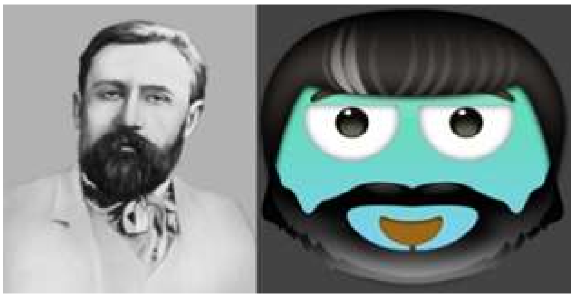

Figure 20: Visual interpretation of the image of BGKU patron – Borys D. Grinchenko.

of the world into the linguistic structure of computer existence modifies the traditional (non-technological) structures of time and space, which include all factors of the existential modes of mankind, including language. The latter acts as the subject of the mentioned transgression, undergoing restructuring at the abstract level of its own ontology. The digital model of the new linguistic picture of the world, in turn, is characterized by absolute nonlinearity of cases with their corresponding defragmentation under the condition of semantization of each of them. The extralinguistic sign is subject to such semantization as an adept of a new abstract in time and space meaning in the linguistic structure of Computer Being (CB). The new sign in the CB is a cyber-concept isolated from the traditional meanings fixed in the appropriate time and space, namely – at Borys Grinchenko Kyiv University with the appropriate corporate standard (turquoise custom colors). Thus, the generated sign (image) is fractalized and concludes three fractal bases – [language] – [emotion] – [feeling].

We conclude that on the one hand, the digitalization of the subject is a timeless and extraspatial phenomenon that narrows the levels of language to an optical sign, without losing meaning, on the other hand – it provides a locational representation of the sign, which can only be understood by the representatives of this location. However, let us also argue the latter in favor of artificial intelligence. After all, it is obvious that the concept of location is also used in artificial intelligence algorithms, for example, to find a way. This primarily applies to the programming of computer games (Haranin and Moiseienko, 2018; Katsko and Moiseienko, 2018), but in the case of generating emoji codifiers projection of the illusion of the whole world (image) and physiognomic and conceptual features, which we rely on in creating emoji for fiction, and a specific image (image of Boris Grinchenko).

Despite the fact that such a digital model is nonlinear, we still single out the anthropic nucleus – [emotion] – among the fractals as a substrate of psychophysiological causal transition and mimesis from language to sensation in the mentioned location. The latter, in turn, synthesizing all the above categories, crystallizes another anthropic nucleus – [space]. The specified kernel on the one hand, frees the subject from existential restrictions, granting the right to any semanticization of a sign, on the other hand – it encodes the subject in digital reality of Computer Being, adiaphorizing both internally – structural levels of language, and externally – the value in social environment. That is why any emoji as a CB object is a signified and a signifier at the same time, which is not observed in its non-digital reproduction and meaning. However, the keyword body (figure 21) that provides the generated image has been modified using the Voyant Tools content analysis and text mining engine, an open source web application that provides corpus analysis of text data. It supports the scientific reading and interpretation of texts or corpus. Therefore, digital text analysis is a significant linguistic addition to the generated sign.

Figure 21: Linguistic mapping of Borys Grinchenko as a corporate concept of the university.

Paying attention to the linguistic complement of the sign, let us return to the poetry of José Ángel Buesa and try to recreate a similar conceptual construct via the use of digital Voyant Tools:

1) calibrated Word Cirrus for the identification of foregrounded concepts in the corpus (figure 22);
2) foregrounded concepts trending tool (relative frequency identification of foregrounded concepts in the horizontally segmented corpus) (figure 23).

Figure 22: Digital corpus identification of key concepts of J. Á. Buesa's "Remember me".

Therefore, the transformative dynamics of emoji at the stage of the conceptual denotation of the corresponding set of signs is realized due to following consequitive developments of the sign meaning construction:

1) the direct vertical expansion to the surface layers of the signs content plane of the core representative substantive elements (|TYPE OF SUBSTANCE: COMPUTER BEING|, |SUBSTANTIVE DISCRETION: SPACE|) (Makhachashvili, 2013),
2) the phenomenological implementation of the former by means of different substrate significant elements of the internal form, in particular:
   - direct nomination – "FACE / EMOJI / SIGN";
   - secondary, metaphorical and/or metonymic, nomination as a mechanism of "computer" semanticization – the content of poetry / physiognomy / mentality / conceptuality; the image of Borys Hrinchenko.

4 CONCLUSIONS AND PROSPECTS OF FURTHER RESEARCH

A multidisciplinary approach to various disciplines (linguistics, literary studies, philosophy of language, psychophysionics, eye-tracking and text-mining technologies, etc.) in synthesis with structures of computer being, namely, with an emoji-body on the Emoji Maker platform allows to create a model of digital semiotic presentation of fiction. Thus, the reader-interpreter, using a specific technological toolkit, a visual iconic sign (smiley/emoji) reproduces the multilateral metalinguistic functionality of the meaning of a sign based on the artistic word. This approach significantly expands the subject of the study and can be applied in classes of linguistic and literary disciplines, as well as in classes in critical and analytical

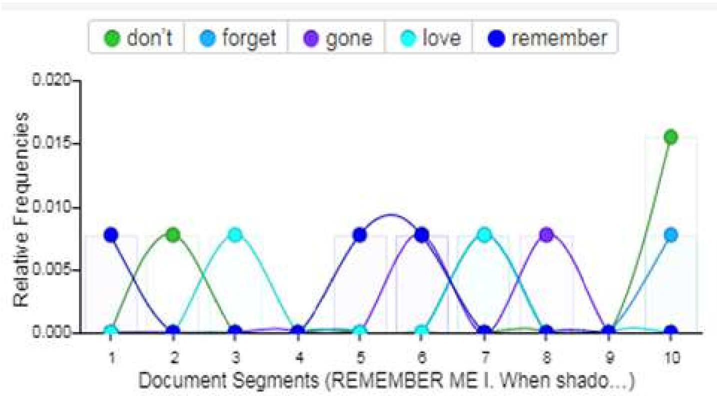

Figure 23: Relative frequency of poetic concepts identification in a horizontally segmented corpus.

reading. Due to the powerful hyper-cybernetization in the world, research on the topic will acquire more and more.

The study outlined the multifunctionality of the computer being emoji corps based on fiction. The Emoji Maker platform attempts to compile the image of a lyrical hero. The created images, hieroglyphs of the 21st century, reproduce the multimodal concept of the metalinguistic field. The sign is both an icon, a symbol and a text. On the verbal language level emoji convey the meaning (dictum) of the signified, on the non-verbal level – the meaning (modus) of the signified. Objective and subjective in a sign are synthesized, and the reproduced image is read through the psycho-physiologist prism, which reconstructs the essence of graphic mimesis in the pedagogical sphere. The technical limitations of the Emoji Maker web platform have made it possible to phenomenologize one's own essential-empirical reconstruction of the image of a lyric hero, which allows one to appeal to the cognitive modeling of content and the development of skills in poetry. The basis of modeling is the theory of similarity, in which absolute similarity is possible only by replacing one object with another, identical to the first in form and content. However, as noted above, poetry is an imagery which understanding depends to a great extent on the recipient's essential empirical experience and on its sensory typology, which corresponds to three main types – visual, audio and kinesthetic (Franken, 2007). Therefore, simulation of exactly the same results is impossible, because only under the condition of individual approach of students to visualized analysis of poetry is it possible to adequately reflect all aspects of functioning of the studied object with the help of a simulated emoji sign. Thus, it is emphasized that during the visualization of verbal information mental frames embedded in the minds of each person, and which are a specific biological identifier of the individual, are foregrounded, which explains the mental, ethnic, national, cultural factors. However, the universality of the emoji language is due to its structure, which is expressed in optical specificity (the shape of a circle, a limited set of tools), which unifies the optical range of any sign. Instead, individual features, dependent on mental or contextual factors, are relevant together with a verbal explanation of the choice of a tool for visualization. In the case of a literary text, the explanation procedure is simplified due to the explicant in the text itself and the identity of the author. In the case of abstract images, much attention is paid to the context. An individual approach to the visualization of corpus data is also reproduced using the web application Voyant Tools, which works with open source, providing text mining analysis. With the support of reading and interpreting texts or corpora, digital text analysis becomes a significant linguistic addition to the generated sign. Moreover, the optical complement can be based both on a specific text (poetry by José Ángel Buesa) and on keywords / concepts (the image of Borys Grinchenko in the context of a specified location: at the eponymous institution – Borys Grinchenko Kyiv University).

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Experimental Verification of Efficiency of the Formation of Information and Digital Competence of Bachelors of Primary Education based on an Integrated Approach

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Keywords: Basic Forms of Educational Process, Control and Experimental Groups, Educational and Methodological Support, Future Primary School Teachers, Information and Digital Training, Integrated Approach, Levels of Information and Digital Competence, Modernization.

Abstract: The article deals with the organization, process and results of the experimental verification of the integrated approach to the modernization of information and digital training of future primary school teachers, which was theoretically grounded in the research. The experiment, which took place in some pedagogical colleges, involved the main forms of the educational process (classes, independent work, practical training, and tests), and included the study of the author's elective course "Modern Information and Digital Technologies in the Educational Process of Primary School". Appropriate methodological support has been developed for the formative stage of the pedagogical experiment. It consists of an electronic textbook "Modern Information and Digital Technologies in the Educational Process of Primary School", lesson plans, tasks for independent work and undergraduate pedagogical practice, test tasks of various types for current and final control, algorithms for practical work, and project topics. The educational process was based on electronic teaching aids such as slide libraries, video clips, interactive exercises and illustrations, electronic textbooks, including the author's teaching aids to the module "Google services in the work of primary school teachers". The two-year formative stage of the pedagogical experiment, which was attended by control and experimental groups of future bachelors of secondary education, confirmed the positive impact of the integrated approach on modernization of information and digital training of future primary school teachers and proved its effectiveness. During the period of its implementation, the levels of formation of cognitive, operational and value components of students' ID competence in the experimental group were significantly higher compared to the levels in the control group. Students in the experimental group were better prepared to conduct online training of primary school children in the conditions of quarantine restrictions caused by respiratory disease COVID-19. The statistical evaluation of the results of formation of students' ID competence in the conditions of realization of the integrated approach to modernization of ID training at the bachelor's level of higher education carried out by criterion 2 proved its efficiency.

1 INTRODUCTION

For the informatized high-tech society, the widespread introduction of information and digital technologies (IDT), their acquisition of the status of a component of the internal quality assurance system of education has become a characteristic feature.

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The training of higher education students with the use of IDT is now mandatory, and in a pandemic, its role has increased considerably. The need to improve educational systems using innovative IDT, modern technical means of communication and implementation of innovative activities is emphasized by the Concept of Information Policy for Development and Promotion of the Information Society (UNESCO, 2003), National strategy for the development of education in Ukraine until 2021 (Verkhovna Rada of Ukraine, 2013), and Conceptual principles of

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pedagogical education in Ukraine and its integration into the European education area (osvita.ua, 2004).

Each educational branch has its own peculiarities of using IDT. In institutions of higher pedagogical education, they consist in the fact that in addition to teaching students with a variety of tools, devices, programs, monitoring learning outcomes, prospective teachers are also prepared for effective use of IDT in their future professional activities. Graduates should have the ability to transfer the acquired knowledge and skills to schoolchildren, taking into account their age and individual characteristics.

Under the conditions of implementing the State Standard of Primary Education (KMU, 2018), the National Strategy for Education Development in Ukraine for 2012–2021 (Verkhovna Rada of Ukraine, 2013), the Concept of implementation of state policy in the field of general reform secondary education "New Ukrainian School" for the period up to 2029 (osvita.ua, 2016), the need to modernize future teachers' training and bring educational programs in line with the needs of the digital economy and information educational environment is emphasized.

The analysis of scientific papers showed that the use of IDT in the educational process is the subject of study by many researchers (Andriievska, 2019; Drokina, 2016; Hurzhii and Lapinskyi, 2015; Kuzminska et al., 2019; Morze and Strutynska, 2021; Morze et al., 2017; Onishchenko, 2015, 2016; Petukhova, 2009; Spirin, 2013; Upatova, 2018, 2019).

In (Krumsvik, 2014; Lavrentieva et al., 2020; McGarr et al., 2021; Porlán and Sánchez, 2016; Røkenes, 2016; Vlasenko et al., 2019), information and digital training of future teachers is positioned as one that ensures the quality of higher education and is important for developing their professional competence. Based on the purpose and objectives of our research, detailed analysis was given to the papers related to training future primary school teachers using IDT and to their readiness to use ICT in the educational process of primary school.

Andriievska (Andriievska, 2019) analyzed training future primary school teachers to use information and communication technologies in professional activities at the didactic level, and substantiated the essence of their readiness for this component in professional activities. The researcher developed a model of training future primary school teachers to use information and communication technologies in their professional activities, created the appropriate educational and methodological support, as well as described meta-subject ID skills and their types at the primary school level, and tested the model experimentally.

Drokina (Drokina, 2016) identified the structural components of information competence of future primary school teachers and substantiated the structural and functional model of its formation in the process of professional training. The researcher structurally presented the information competence of the future primary school teacher with information-cognitive, information-methodical, information-computer components and professionally important psychological and pedagogical qualities of future primary school teachers. The analysis showed that both researchers focus on methodological training of students for the use of IDT in primary education, and focus more on the result of training bachelors of primary education in the form of readiness to use IDT in the educational process of primary school and the graduates' information competence.

Onishchenko (Onishchenko, 2016) proved that the formation of future primary school teachers' information competence depends on the informatization of higher pedagogical education.

As in the previous studies, in the monograph and the dissertation of Petukhova (Petukhova, 2007, 2009) attention is focused on the result of developing future primary school teachers' IT competence. It is noteworthy that the researcher revealed the specific features of the use of IDT depending on the information and communication environment of students' professional training.

Upatova's research was devoted to the system of methodical training of future primary school teachers and identifying their readiness for realization of professional methodical activity that "provides ... use of modern pedagogical technologies, methods, receptions and ways of effective training and education of younger schoolchildren" (Upatova, 2019, p. 41). The fact that during the experimental work the teachers – winners of the professional competition "Teacher of the Year" – conducted a master class with students on the topic "Using IDT at different stages of the lesson in primary school", and during the internship students mastered modern methods of primary education, including methods of using IDT in the educational process of primary school" (Upatova, 2019, p. 29), shows that the researcher pays attention to the information and digital training of future primary school teachers. However, IDT and targeted ID training of students were not the main priorities of the research.

Without lowering the value of scientific achievements of the above-mentioned researchers, it should be noted that the modernization of the training of bachelors of primary education, which would comprehensively cover all forms of organization of the educational process, has not yet been the subject of targeted pedagogical research. Therefore, the formation of information and digital competence as learners' key competence (Shokaliuk et al., 2020) remains a topical task of the theory and methodology of professional education.

In our previous publication (Yaroshenko et al., 2020), the content and component composition of information and digital competence (IDC) of the future primary school teachers, the essence of the integrated approach to modernization of information and digital training of bachelors of primary education were substantiated. The theoretical foundations of training bachelors of primary education based on the integrated approach revealed in it were taken as a basis of development of a technique of a formative stage of pedagogical experiment on verification of its efficiency.

2 RESULTS AND DISCUSSION

The purpose of the article is to prove the efficiency of the integrated approach to modernization of information and digital training of future primary school teachers in the conditions of real educational process of pedagogical colleges at the first (bachelor) level of higher education. The integrated approach to the modernization of information and digital training of bachelors of primary education concerns the content of curricula and lectures, plans of practical and seminar classes, organization of students' independent work, pedagogical practices and control measures (Yaroshenko et al., 2020). There is to be consistently revealed what has been done for each position to provide ID training for students based on the integrated approach and to create appropriate educational and methodological support of the educational process.

The content of disciplines "Information and Communication Technologies, Technical Means of Teaching", "Practical Course of Informatics with Elements of Programming", "Methods of Teaching Informatics Education" is supplemented by information on professionally oriented use of IDT in the educational process of primary school and the possibility of using network services as pedagogical tools. The list of learning outcomes has been expanded due to the following abilities: to use learning tools that involve IDT; to implement IDT to ensure the quality of student learning; to conduct educational activities in the digital educational environment, taking into account the educational needs and characteristics of students; to monitor students' educational activities, their progress in learning and provide appropriate support with digital tools; to adjust and adapt the educational process on the basis of data obtained with the help of digital technologies; to use digital services to create electronic documents and organize online events to communicate with students and parents; to be aware of the role of digital resources in the life of citizens and society.

The elective course "Modern Information and Digital Technologies in the Educational Process of Primary School" was added to the required disciplines of the ID training cycle available in the curriculum. It is aimed at developing students' information and digital competence in the conditions as close as possible to the real educational process of primary school. Such conditions were created by means of developing cognitive tasks, the implementation of which required visiting a general secondary education institution either to do the tasks, or to verify the reliability of the result.

The colleges have created a system of digital education consisting of:

- information resources (media, video, audio, biblio resources, photo, graphics, educational portals, Internet sites);
- telecommunications (network and mobile environments, media, postal services);
- educational process management systems (user authorization, testing, content, ratings, personal and collective information spaces – site, blog, chat, forum, mail, database).

Two credits were allocated to study the course "Modern Information and Digital Technologies in the Educational Process of Primary School" (36 hours of classroom classes and 24 hours of independent work). The final control measure was held in the form of a test. The content is represented by four logically complete modules:

module 1. Theoretical and methodological principles of informatization of primary education and digital competence of pedagogical workers;

module 2. Development of teachers' digital intelligence: a guide to digital tools in the effective management of the educational process;

module 3. Google services in the work of primary school teachers;

module 4. Digital technologies in management, organizational and methodical work of primary school.

Objectives of the course "Modern Information and Digital Technologies in the Educational Process of

Primary School" are to deepen students' understanding of the scientific principles of building the educational process using information and digital technologies; to form higher education students' skills of optimal use of IDT in working with younger students; to find out the influence of the educational and information environment on various aspects of the development of the student's personality; to deepen the knowledge of methods of application of information and digital technologies in the educational process of primary school.

Another feature of this course is the high proportion of creative (project) tasks. The topic of the projects is the development of electronic teaching materials (presentations, demonstration digital teaching materials, which can be used in primary school lessons during pedagogical practice). The educational process of primary school is designed with the use of information and digital technologies in lessons on various subjects and extracurricular activities.

While studying the discipline "Modern Information and Digital Technologies in the Educational Process of Primary School" along with traditional teaching aids, the author's electronic manual presented in digital form is used for the module "Google services in the work of primary school teachers". With its help, students mastered the content of the module with the same name. The manual contains a brief description of the main theoretical material, examples of practical tasks, exercises for independent work; tasks for self-control, including tests. The manual has a convenient navigation; with its help which students can easily move to the section they need.

The electronic manual also contains tasks that involve student group work using network services. During the group learning activities, the resource potential of social networks and mobile applications is used, which allows students to create a group for free communication, online exchange of information and access to the Internet resources. While working, small groups gain access to Google Drive, which downloads all the information needed to complete a group task, giving access to each member of the group, allowing them to work together to create a presentation, make adjustments, suggest ideas, discuss them, and share decisions.

Working in small groups using network services, students have the opportunity to work with other applications and platforms, including messengers such as Skype, Viber, Zoom, Telegram, to create chat groups, which is quite convenient when performing group projects or group tasks.

In the manual "Modern Information and Digital Technologies in the Educational Process of Primary school" considerable attention is paid to student independent work, which is the main form of development of students' competence in the time free from compulsory education. Independent work is organized using the Google Classroom service. All materials for independent work are placed in the Classroom environment, software and methodical support of remote forms of interaction of students with the teacher through dialogue communication "student – content", "student – teacher", "student – student" is adjusted. Tasks with use of technology of electronic training (E-learning) are offered for students' independent work.

Doing the elective course "Modern Information and Digital Technologies in the Educational Process of Primary School" proved to prepare students of the experimental group for pedagogical practice in distance learning, introduced in spring 2020 through restrictive anti-epidemic measures to prevent the spread of the respiratory disease COVID-19. Under the circumstances, the students were able to organize online learning for schoolchildren, help teachers create and select tasks, grade, comment and organize effective communication with primary students and their parents in distance learning.

Lectures were diversified by interactive work with students, they applied problem-based learning; expanded teaching aids using interactive whiteboards, phantoms, cases, tests, videos; conducted lectures-presentations, dual lectures, lectures-consultations and lectures-press conferences.

The use of audiovisual media, digital devices, telecommunications, video computer systems, multimedia, interactive whiteboards, and virtual reality media has become mandatory in practical classes. The content of tasks for group and individual activities was expanded due to professionally oriented tasks related to the use of IDT in school educational process, introduced modeling and conducting in the classroom parts of lessons (micro-teaching) using ID-tools, as well as lessons the didactic purpose of which was development of students' digital literacy. Educational communication of students in practical classes was provided by organizing group learning activities, and using game modeling of pedagogical situations to develop practical skills.

In the context of the implementation of an integrated approach, independent work has also undergone significant changes. It involved the use of e-learning technology. In order to use them during the study of the course "Modern Information and Digital Technologies in the Educational Process of Primary School", an electronic teaching kit was created which included syllabus, lecture course, instructions for practical work, recommendations for independent work, test control tasks , criteria for assessing students' achievement, and a glossary. In addition, we suggest using the G Suite network services to create and maintain one's own blog based on Blogger or Sites Creator to create and maintain a personal website. With their help, future primary school teachers have the opportunity to share their own developments and achievements in compliance with copyright and use the experience gained not only during training, but also in further professional activities.

Google services allow to process text documents in almost all formats, build charts, graphs and tables (Google Sheets) without installing additional programs on gadgets, as well as present the results of one's activities in the form of self-created presentations.

All materials for independent work are placed in the Classroom environment, the program and methodical support of remote forms of interaction of students with the teacher through dialogue communication "student – content", "student – teacher", "student – student" is adjusted. Studying the disciplines of general professional training, students independently used electronic dictionaries, encyclopedias, reference books, textbooks, computer simulators and tests, information resources of the Internet.

An integrated approach to the modernization of ID training for bachelors of secondary education also applies to their practical training, which has been and remains an important form of the educational process. At the time of the formative stage of the pedagogical experiment, there were two practices – educational research and student teaching. The program of both kinds of practice provides for trial and credit classes in primary school subjects, and work as a teacher in the performance of all the duties. Student teaching practice allows students to test knowledge, skills, and values acquired during the study period in the real educational process. The internship lasts six weeks, and the curriculum provides for 6 credits. One of the main tasks of student teaching practice is to develop the ability to use modern IDT, working as a primary school teacher. Students were in a real educational environment where they studied the positive experience of using IDT in primary school; analyzed lessons in which digital educational resources were used; produced handouts for young learners using IDT and digital demonstration materials for the lesson. Students gained experience working with parents, in particular, provided assistance in organizing the work of schoolchildren with electronic educational resources; conducting public speeches to teachers and parents with reports and messages on the use of modern innovative educational materials with a digital component; formed a methodical treasury of digital educational resources for primary school.

In general, the process of training future teachers uses a wide range of types of control measures (oral examination, written tasks of control work, questionnaires, testing, etc.). All of them were preserved in the experimental methodology, but supplemented by the protection of the internship report, prepared in the form of a presentation, and expert evaluation of projects completed by students (methodologists and teachers acted as experts). Projects performed by students of the experimental group in the conditions of online learning on the topic "Organization of online learning of primary school students in the conditions of restrictive quarantine measures" were evaluated. Students had to create distance materials from one (optional) subject of primary school. The project had to contain methodically processed theoretical material, as well as drawings, videos, interesting presentations, crossword puzzles, tests, interactive exercises, etc., developed at https://learningapps.org.

Under the conditions of quarantine, students implemented the developed projects in the classes assigned to them, where students studied distance courses developed by trainees. Experts evaluated the content of the developed fragment of the distance course, the volume, compliance with the curriculum, the form of presentation of educational material, content with interactive exercises, online tests, audio and video materials.

Thus, in order to conduct a pedagogical experiment, all forms of organization of the educational process and types of educational activities provided for in Article 50 of the Law of Ukraine "On Higher Education" were modernized. This allowed organizing and conducting an experimental test of the effectiveness of the formation of ID-competence of bachelors of primary education based on an integrated approach.

The purpose of the ascertaining stage of the pedagogical experiment was to identify residual knowledge and practical skills that characterize the digital competence of college graduates who have obtained the educational qualification level of junior specialist (professional junior bachelor) and expressed a desire to continue their studies at the bachelor level. At this stage, 112 students of Bar Humanitarian Pedagogical College named after Mikhailo Hrushevsky, Uman Humanitarian Pedagogical College named after T.H. Shevchenko and Khmelnytsky Pedagogical College of Khmelnytsky Humanitarian and Pedagogical Academy took part in the experiment. All of them were entrants on the basis of basic general secondary education, and after obtaining the degree of professional junior bachelor they continued their training at the first (bachelor's) level of higher education with a reduced period of study (120 ECTS credits).

Before the formative stage of the pedagogical experiment, the participants of the statement stage formed a control (54 people) and experimental (58 people) groups. The training of students in the control group was carried out according to the established method, and in the experimental, it was based on an integrated approach to training modernization. The formative stage of the pedagogical experiment lasted 2 years. At the stage, it was necessary to study such disciplines of information and digital training as "Practical Course of Informatics with Elements of Programming" and "Methods of Teaching Informatics Education", an elective discipline "Modern Information and Digital Technologies in the Educational Process of Primary School" and do teaching and undergraduate practices.

Special for the formative stage of the pedagogical experiment was the fact that throughout the period of its implementation, college students were under the active influence of the educational environment of primary school, in person and remotely interacted with students and teachers of primary school. Prospective teachers studied the course "Modern Information and Digital Technologies in the Educational Process of Primary School" included in the variable part of the curriculum; higher education students carried out classroom and independent work as described above. Group learning activities were optimally combined with frontal and individual work. A mandatory task of all types of practices was the systematic use of information and digital technologies in the educational activities of educational institutions of the first degree (Yaroshenko et al., 2020).

The initial and final results of the formation of students' ID-competence during the formative stage of the pedagogical experiment are shown in table 1.

The dynamics of the formation of components of ID-competence of higher education students, during the formative stage of the pedagogical experiment is analyzed using histograms of figures 1–3.

In figure 1, it can be seen that after the formative stage of the pedagogical experiment the number of students with a high level of cognitive component of ID competence in the experimental group increased by 25.8% and there were 25.9% less students with an average level. In the control group, the number of students with a high level of formation of the cognitive component of ID competence increased only by 7.4%. One third of students in the control group (35.2%) had an average level of cognitive component of ID competence, which is 12.8% more than in the experimental group.

Figure 2 shows that during the formative stage of the pedagogical experiment the number of students with a high level of formation of the operational component of ID competence in the experimental group increased by 34.5% and at the same time the number of students with an average level of the studied phenomenon decreased by 34.5%. In the control group, all the three levels underwent inconspicuous changes (changes ranged from 1.8% to 3.7%).

Comparison of diagnostic data on the levels of formation of the value component of ID competence of students in control and experimental groups (figure 3) indicates a tendency to change the levels of formation of ID competence, which took place in the previously considered cognitive and operational components. Thus, in the experimental group, the number of students with a high level of formation of the value component of ID competence increased by 38%. The number of students with an average level decreased by 34.5%. In the control group, students with an average level of the value component formation of ID competence dominated (46.3%), and only 20.4% of higher education students had a high level of the value component.

The results of the formative stage of the pedagogical experiment were processed using statistical evaluation by the criterion χ^2. Using the formula for calculating the empirical value $\chi^2 = 7.13$ was obtained. After comparing the obtained value with the critical value given in the statistical tables, the ratio $\chi^2 = 7.13 > \chi^2_{0.05} = 5.99$ was obtained, which indicates the statistical reliability of the results of the formative stage of the pedagogical experiment.

Thus, the results of the pedagogical experiment indicated the effectiveness of ID-competence formation of bachelors of primary education based on an integrated approach.

3 CONCLUSIONS

1. Based on the analysis of the scientific publications, it was found out that the ID training of students of higher pedagogical education has its peculiarity. Its essence is that the IDT is both a means of professional training of students, and the subject of comprehensive study for further effective use of the IDT in future professional activities. The interconnectedness determines the formation of future primary school teachers' ability to use information and digital technologies in the educational process of primary school, in order to develop digital literacy of primary school chil-

Table 1: The results of the initial and final measurements of students' ID competence in the control and experimental groups.

ID competence components	Levels	Groups							
		Control				Experimental			
		Measurements							
		Initial		Final		Initial		Final	
		People	%	People	%	People	%	People	%
Cognitive	High	12	22.2	16	29.6	11	19	26	44.8
	Sufficient	16	29.6	19	35.2	19	32.8	19	32.8
	Average	26	48.2	19	35.2	28	48.3	13	22.4
Operating activity	High	11	20.4	12	22.2	12	20.7	28	48.3
	Sufficient	17	31.5	18	33.3	18	31	21	36.2
	Average	26	48.2	24	44.4	28	48.3	8	13.8
Value	High	13	24.1	11	20.4	10	17.2	32	55.2
	Sufficient	13	24.1	18	33.3	22	38	20	34.5
	Average	28	51.8	25	46.3	26	44.8	6	10.3

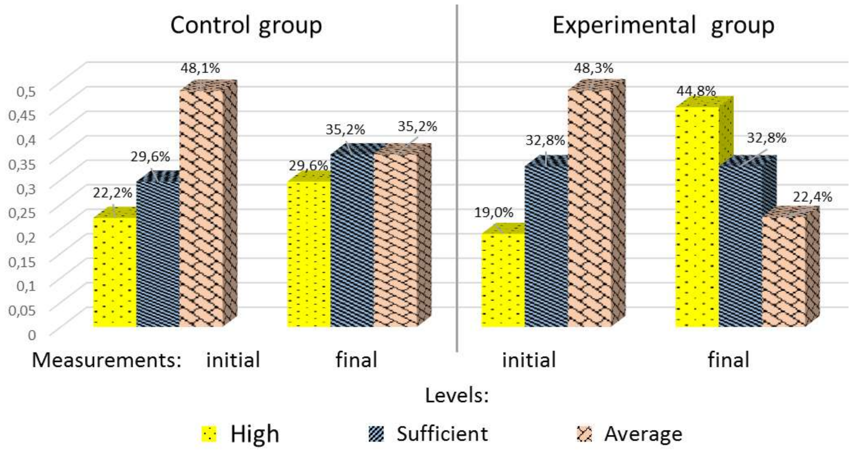

Figure 1: Dynamics of formation of the cognitive component of ID competence of control and experimental group students.

dren.

2. The developed educational and methodical support of the integrated approach to modernization of information and digital training of future bachelors of primary education is described. It applies to all major forms of educational process. In the experimental teaching, it was implemented in the content of curricula and lectures, plans of practical and seminar classes, students' independent work, pedagogical practices and control activities.
3. The experiment was aimed at confirming the effectiveness of implementing the integrated approach to the formation of future primary school teachers' ID competence. It was based on the systematic use of information resources (media, video, audio, library, photo, graphics, educational portals, websites), telecommunications (network and mobile) environment, media, postal services); educational process management systems (user authorization, testing, content, ratings, personal and collective information spaces such as site, blog, chat, forum, mail, database).
4. It was proved that the elective course "Modern Information and Digital Technologies in the Educational Process of Primary School" is a system forming factor in the integration of knowledge, skills and values acquired by students. In the context of the restrictive anti-epidemic measures caused by COVID-19, this was particularly topical. Students who successfully completed the course created distance-learning materials for primary school subjects. They demonstrated the ability to organize the educational process using the platform Google Classroom for distance and blended learning.
5. The obtained results of initial and final measurements of levels of formation of components of students' ID competence in control and experimental groups proved methodical expediency of organization and carrying out of pedagogical experiment

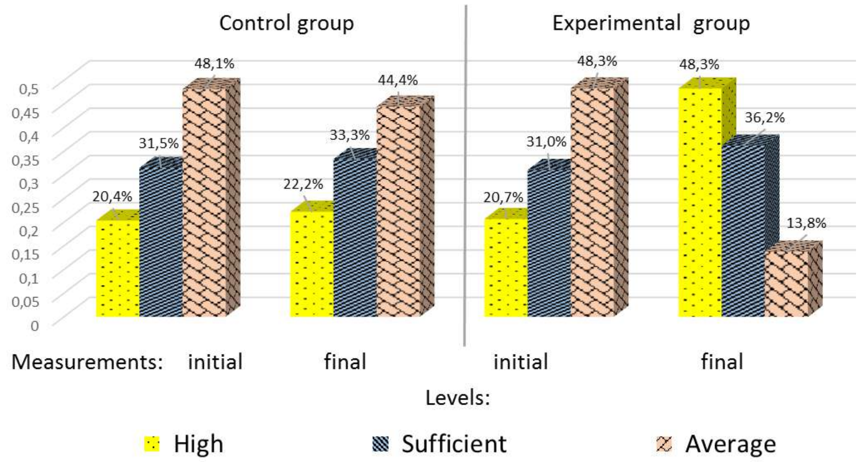

Figure 2: Dynamics of formation of operational-activity component of ID-competence of control and experimental group students.

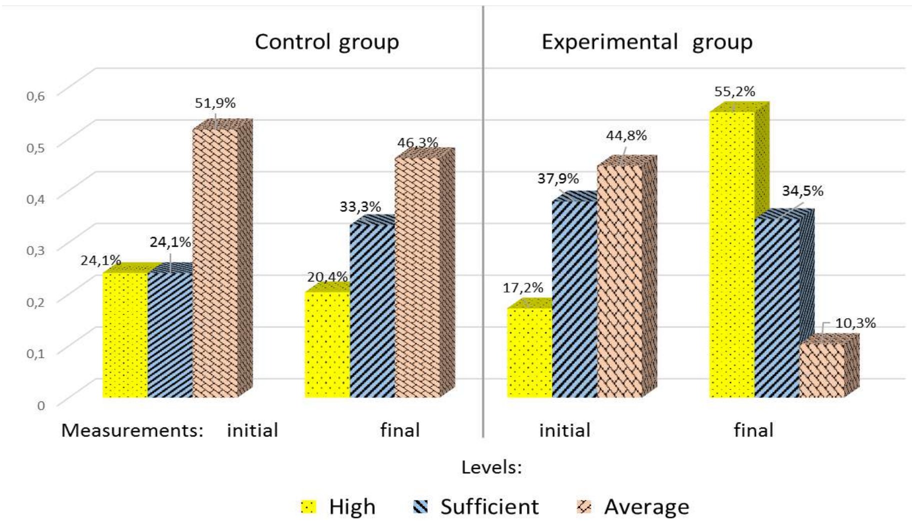

Figure 3: Dynamics of formation of the value component of ID competence of control and experimental group students.

which experimental factor was the integrated approach to modernization of ID training of future bachelors of primary education. During its implementation, ID competence of students in the experimental group was formed more successfully, and they achieved better indicators of the formation of cognitive, operational and value components of the studied phenomenon than the students of the control group. Statistical evaluation of the results of the pedagogical experiment using the criterion χ^2 proved the reliability of the obtained results, and, consequently, the effectiveness of modernization of ID training of future primary school teachers based on the integrated approach.

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Development of Augmented Reality Mobile Application in Physics to Study the Electric Circuit

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Abstract: Using the virtual teaching aids with AR technology in different spheres of education, including physics, has been analysed. The analogy between physical and electronic models has been drawn and the development of mobile app to study simple electric circuit has been substantiated. The reasonability of creating the technique of the augmented reality mobile apps has been given. The milestones in the development of the augmented reality app have been outlined: development of electronic models, installation of the game engine Unity3D, development of all program scenes, operation testing and demonstration. Using the scenarios for electronic models rotation and movement has been particularly focused on. Own developed augmented reality mobile app for mobile devices “Augmented reality program to study the simplest electric circuit” has been presented. The created mobile app reads, recognizes the designer marker and displays the product electronic model on the screen. It is established that the augmented reality program developed by the team of authors as the mobile teaching software can be used to do the tasks for the students’ individual work, as well as for the classroom studies at the universities.

1 INTRODUCTION

Rapid development of information computer technologies and their mass use in all spheres of everyday life and professional activity mainstream the need in their use in the educational process. Recently, the digital technology has made a great leap in development and expansion of the spheres of use. One of the teaching aid to help students in learning physics is the augmented reality (AR). AR is an attempt to combine the real and virtual world created with the help of computers so that the line between them becomes too fine (Chena et al., 2015; Nechypurenko et al., 2018). Simply to interpret, the AR can be defined as a real environment added to the virtual objects (Ismail et al., 2019).

At the outset of creation of the augmented reality, it was mainly used in the military and computer fields. Today this technology has entered virtually all spheres of social activity of a man: economics, medicine, education, architecture, advertising, etc. (Andrea et al., 2019). The tourist mobile apps (mobile tour guides) where the tips and interesting facts from the modern life and the past are displayed on gadgets by GEO tags and GPS have become common (Lu and Liu, 2015).

In its turn, each augmented reality mobile app uses virtual electronic models. A number of researches (Alvarez, 2011; Mon and Cervera, 2013; la Torre Cantero et al., 2013; Saorín et al., 2017) show the comparative data of the used physical and electronic models.

3D physical models (figure 1) are used in the learning of physics to study the electric circuit et al.

The use of physical models also has several disadvantages, such as: high cost, which leads to the purchase of models only from the basic topics of the discipline. In the process, models wear out and break their parts, and sometimes, due to inadvertence and difficulty in moving, entire models are destroyed. Usually, physical models belong to educational institutions and require special storage, which in turn

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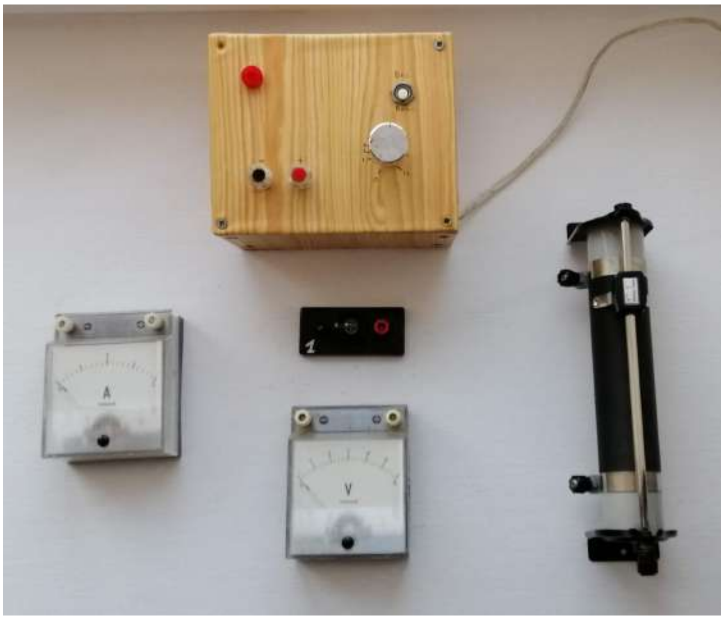

Figure 1: 3D physical models in teaching physics to study the electric circuit.

makes it impossible for a student to constantly have free access to objects. These and other factors limit the possibility of the full use of models in the educational process. To solve these problems, it is advisable to use virtual models of products. They are easily using on mobile Internet devices with AR.

Having analysed the opportunity to replace the physical (material) model with the 3D electronic model in the course of learning, the researchers noted that the students felt comfortable with the electronic models.

Representation of digital models on tablets and smartphones is usually built upon the options of the augmented reality that is attracting the educational community more and more because it not only includes the most advanced technology but also helps the user protect against information overload. In contrast to multimedia and virtual reality, the AR represents the electronic objects as holograms superimposed on the real world (Mona and Munindre, 2013). The augmented reality partially supersedes the physical world that includes the additional digital information (for example, virtual flat and three-dimensional objects) to expand and simplify the perception of real models (Hung et al., 2016).

Even today the computer software and virtual laboratories give new opportunities for teachers and students in presenting the learning material and organising the educational process. Such technologies as virtual (VR) and augmented (AR) reality are leading in this area. They not only transform the abstract learning material in the interactive knowledge but also represent the information in the form of visual, voice and dynamic content (Cai et al., 2017; Dunleavy et al., 2009; Radu and Schneider, 2019).

Some studies show that using the AR technology in education can significantly increase the learning efficiency (Garzón and Acevedo, 2019; Garzón et al., 2019).

As shown in (Morales et al., 2019), the augmented reality in the higher education is used in various fields of knowledge. In mathematics, it makes it easier to explain abstract models, visualizes mathematical objects and simplifies understanding their place and location in the space; in such subjects as physics, it helps modelling virtual laboratories reproducing the physical phenomena; and also promotes learning motivation in computer studies (Majid et al., 2015). Such programs are used by students both in classrooms, and outside.

The augmented and mixed realities have become common in technical sciences as well. In the (Kanivets et al., 2019), we have demonstrated own development for teaching students of technical faculties in the discipline “Engineering Graphics”.

Cai et al. (Cai et al., 2014) have shown the use of the AR technology in studying chemistry for visualization of microscopic world of atoms, molecules and crystal lattices. Lu and Liu (Lu and Liu, 2015) describe the learning model on the basis of digital games that includes the augmented reality technology for primary pupils on the issues of marine ecology and water resources. They point out more qualitative memorizing of new information, better mastering the competencies and higher success level of pupils with low academic performance.

In social sciences, the augmented reality is used in studying history and subjects reproducing the patrimony. Such technologies make it possible to get to know about historical and cultural events of the region, promote for better memorizing of historical dates and events (Lim and Lim, 2020).

For the Altmeyer et al. (Altmeyer et al., 2020), the AR seems to be especially applicable for giving information during experiments as it can be used for integrating both the physical and virtual laboratory work.

The efficient use of AR technology, including in physics, is verified by researchers from different countries of the world. Thus, according to the Ismail et al. (Ismail et al., 2019), branches of physics, such as electrics and magnetism, are explicate and the students face difficulties in studying even the basic notions, as a result, the students treat physics as difficult and dull. The authors note that to develop basic understanding, it is better to use the information technology in the form of multimedia or software that gives an opportunity for the students to visualize the learning material.

Ibáñez et al. (Ibáñez et al., 2014) show the experiment with senior pupils on checking the good influence of mastering knowledge in physics when the AR mobile app is used. As a result, the pupils that used the AR technology perceived the obtained knowledge better and quicker. In their turn, Akçayır et al. (Akçayır et al., 2016) studied the influence of using the AR on practical skills of students and proved that this technology had helped them to improve their knowledge and skills after doing relevant laboratory works. Most recently, Fidan and Tuncel (Fidan and Tuncel, 2019) found out that the problem-based learning integrated with the AR had improved the success level of pupils and promoted their better attitude to physics.

Therefore, physics as the discipline has been already focused on the augmented reality, and the researchers are common in developing the literature and AR software (Cai et al., 2021).

The literature review showed that the AR in the learning process of different countries had become widely used. The operation principles of mobile apps, their influence on qualitative indicators of the knowledge mastered by the students are described, but the basic instructions on development of similar programs are not given. That is why the objective of our research is to consider the method of creation of mobile app in physics to study simple electric circuits with the use of the AR technology.

2 STUDY RESULTS

The AR mobile app was developed on the PC with the following characteristics: Intel Core i5-4440, RAM 16 Gb, video card NVIDIA GeForce GTX 1050 Ti, network card, external universal webcam, installed Windows 10 (64-bit version).

The AR app is developed with the use of the AR platform Vuforia (Vuforia, 2020). In the Target Manager account, we create a new database and upload a target image (figure 2) that is the electric circuit diagram with QR code being of practical value and used for program installation on mobile device.

The target image is processed by computer vision aids and assessed according to the rating. The best images have 5 stars. They are quickly and qualitatively recognized by the application. Minimum recommended value is 3 stars. The database is uploaded from target images to Unity3D (Katsko and Moiseienko, 2018).

In these researches, we use Version 2018.4.15f1 (64-bit) Unity3D (Unity, 2020) for which installation we made additional settings of Android SDK (developer.android.com, 2020) and JDK by Oracle (Oracle, 2020). These applications are necessary for proper compilation of the Android mobile apps.

At the initial stage of the mobile app development, we design the electronic models. These models are displayed on the screen of the mobile gadget when the program is in operation. According to the electric circuit diagram (figure 2), the models of rheostat, amperemeter, voltmeter, current-controlled switch, incandescent lamp on pedestal, accumulator and connecting wires have been produced. Each electronic model consists of several parts that will interact when the mobile app works. For example, the rheostat model (figure 3) consists of ceramic base 1 with wire 2 wound. The base is attached to two supports 3 by bottom bar 5. Slider 4 moves along the top bar 5. Clamps 6 with washers 7 are intended to connect the connecting wires.

The electronic model of voltmeter (figure 4) is built in a similar way and consists of housing 1, glass 2, grade 3, pointer 4, magnetic and electric system 5, clamps 6, washers 7, plus 8 and minus 9 signs.

Such complicated models should have been developed in order the rheostat slider can move along the bar and the voltmeter pointer can go at relevant angle when the mobile app works. The glass is made transparent, and when the pointer goes, the grade values can be seen.

All electronic models for mobile app were designed in Kompas-3D (Ascon, 2020) and then saved in the OBJ format. To make the models, other CAD

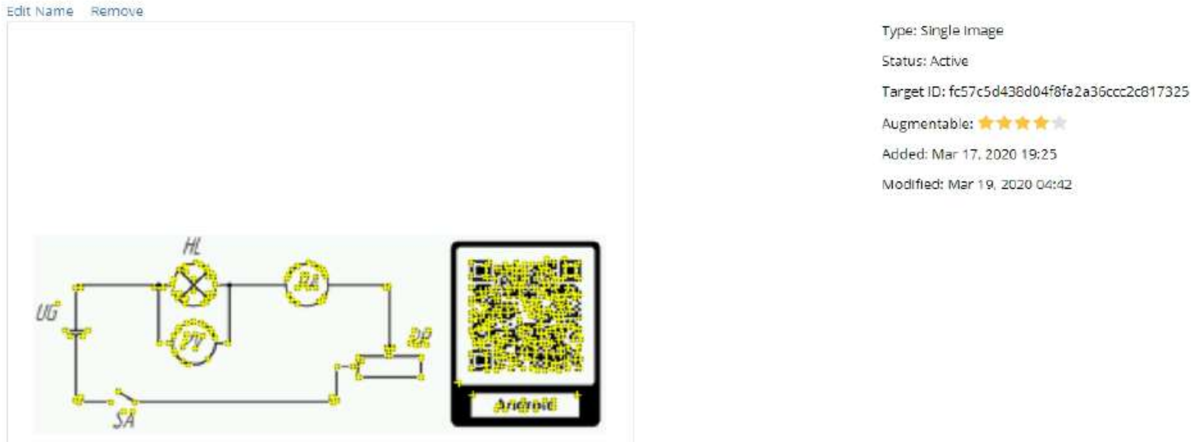

Figure 2: Target image recognition system in Vuforia.

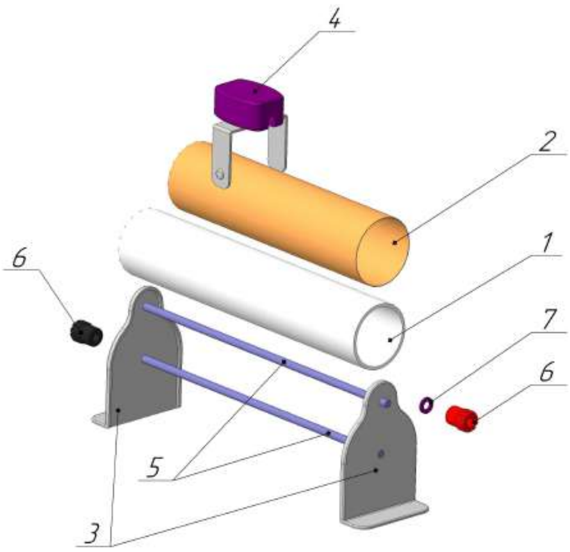

Figure 3: Electronic model of rheostat.

programs, such as AutoCAD, Inventor or Solidwork, or 3D modelling programs, such as 3ds Max, Cinema4d, Maya, Blender, can be used.

The mobile app development is started with the main menu scene. In the hierarchy window, the standard cam is changed for AR, ImageTarget and component Canvas are uploaded. At own discretion, the following frame parameters are set: position, size, colour and transparency. By the Button command, we add the future menu buttons. We move, scale and rename them as shown in figure 5.

In the program test run in Unity3D using the Play button, we will see the same image as given in figure 5. Once the button clicked, they are animated but no response occurs. For correct work of any objects (buttons), it is necessary to add a new component – a scenario to indicate which action is to be performed

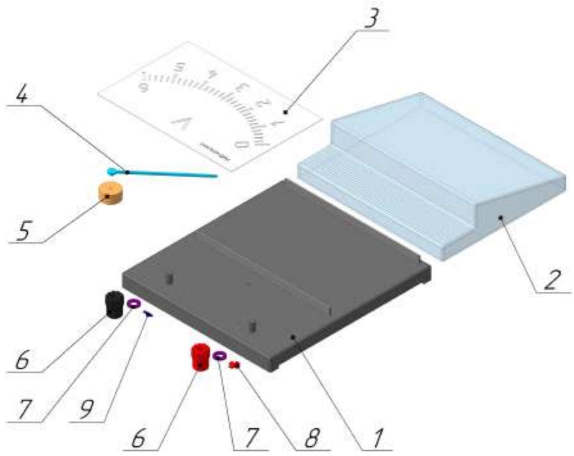

Figure 4: Electronic model of voltmeter.

when activated. Switching between program scenes is implemented by the SceneManager script:

```
public class LoadScene : MonoBehaviour {
  public void SceneLoader(int SceneIndex){
    SceneManager.LoadScene (SceneIndex);
  }
}
```

This code has the derived public class LoadScene. The public method Public void SceneLoader() describes the variable int SceneIndex that makes the script universal for switching between all program scenes by specifying the relevant scene number. Once the Button clicked, the SceneManager command is activated and implements switching to the specified scene number.

This mobile app has three work areas:

1) theoretical training;
2) theory checks (tests);
3) practical training.

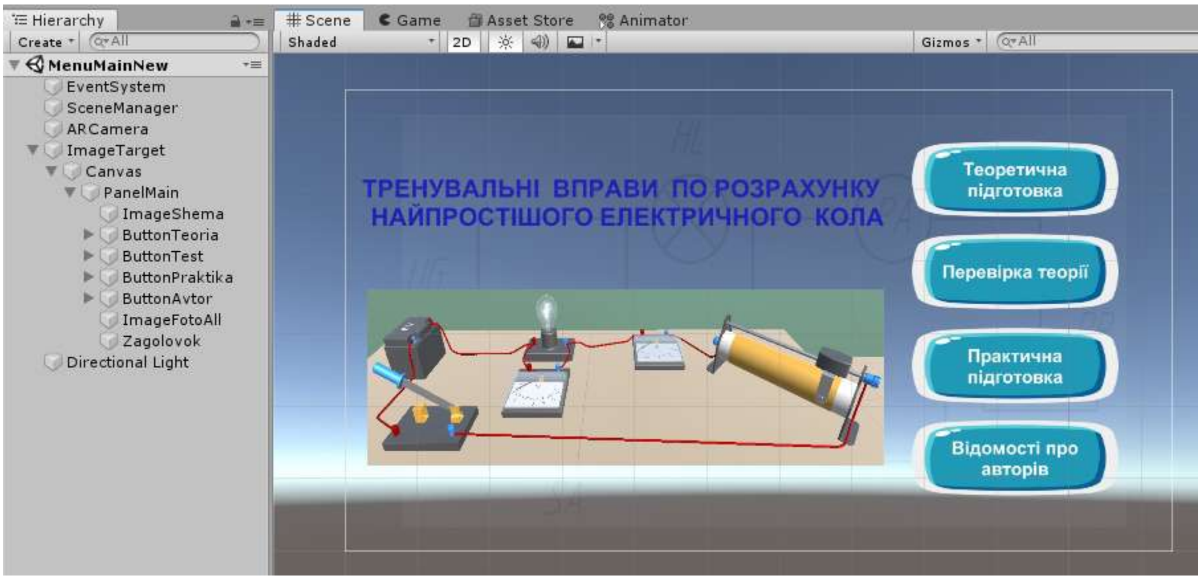

Figure 5: Main Menu.

Each area is implemented in the form of individual scene.

The development of the first scene is started by uploading the Canvas component. The color and transparency of the Panel tool are set. Using the Button command, the buttons of theoretical information about the lamp, amperemeter, voltmeter, rheostat, current-controlled switch and accumulator are added. We move, scale and rename them as shown in figure 6.

The theoretical information about each element of the diagram is given in the ScrollView components. By default, the ScrollView components are located outside the scene and invisible for viewer. The effect of ScrollView displaying from the top to the mid-screen once the relevant button is clicked is implemented by the Animator component. To do this, two animations for displaying and hiding the theoretical information were recorded. For each ScrollView, the Animator component was added and the ScrollViewHL animation controller responsible for animations was selected (figure 7).

In order the program understands that once the required button is clicked, the proper theoretical information is displayed in the scene, it is necessary to select Animator.Play in the button settings in section On Click () and upload the displaying object, for example, the ScrollViewHL(Animator) component containing information about the lamp, as well as to write the displaying animation ScrollViewHLOpen (figure 8).

The hiding effect of the ScrollView components is implemented in a similar way once the “Back” button is clicked.

The next development stage of the application is scene design based on the theory checks. Figure 9 shows the test scheme. This scheme is activated by the information button.

The operation principle of the theory checks section is as follows: the buttons with conventional symbols of the electric diagram elements are to the right of the screen. Once the button is pressed, the list with equipment images drops down from the top part of the screen. The equipment image corresponding to the conventional symbol can be selected using the slider. Once the selected image is clicked, there can be two options:

1) incorrect answer – appears on the screen of the gadget and there remains an option to continue selecting the equipment to correspond to the conventional symbol;

2) correct answer – appears on the screen of the gadget; the list with equipment images is hidden in the top part of the screen, and the electronic model of the device is displayed in the proper point of the scheme.

Designing the theory checks scene is similar to the theoretical information scene. The development was started with uploading the electronic models of tables and figure of the electric diagram. The electronic models of rheostat, amperemeter, voltmeter, current-controlled switch, lamp on pedestal and accumulator were uploaded to the diagram. All models, after being scaled up, were placed according to their symbols. By default, the models are inactive, that is invisible. Then, the Canvas component is added and

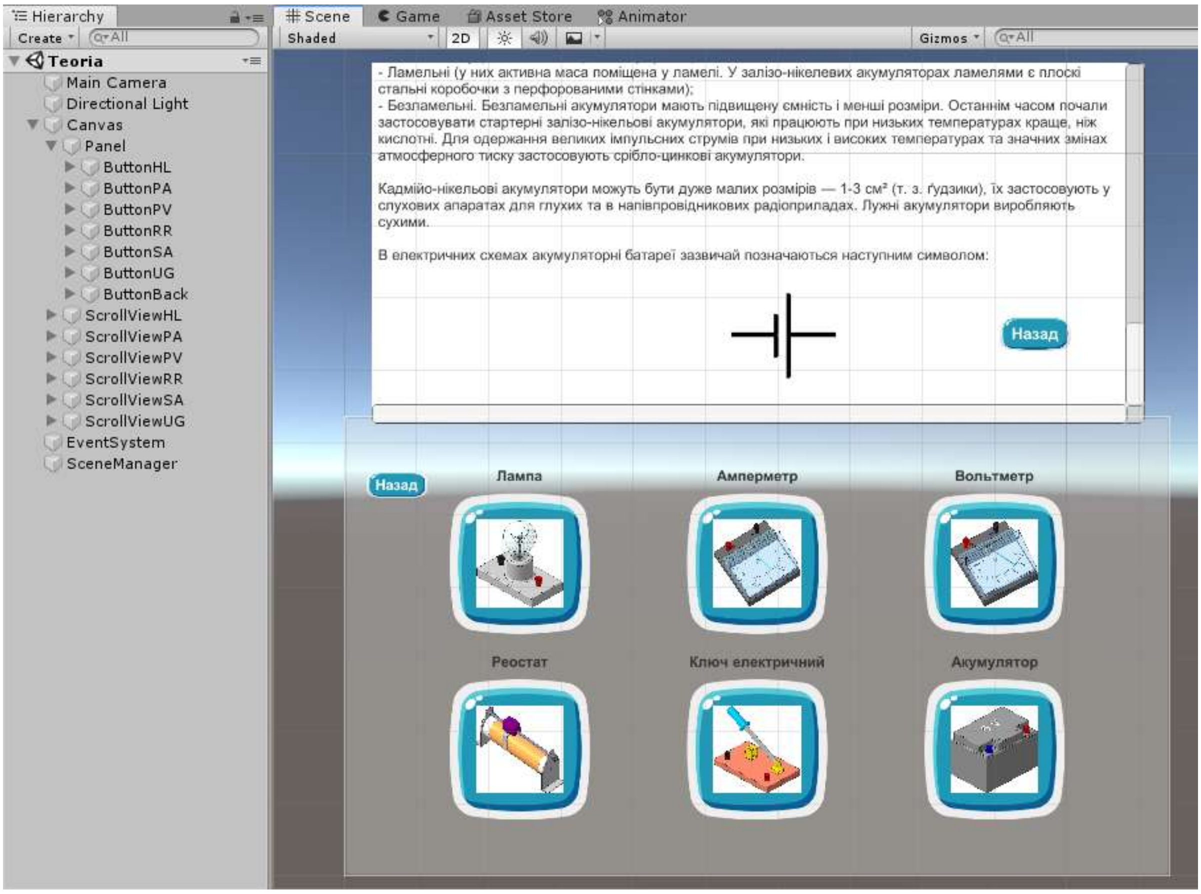

Figure 6: Scene of theoretical training.

the transparency of the Panel tool is set. Using the Button command in the Canvas right part, the buttons are added and the conventional symbols of the electric diagram elements superimposed on them. The displaying effect of ScrollView with equipment options is implemented by animation according to the above method. The equipment images in ScrollView are made via the Button command. Figure 10 shows the Button settings in section On Click () by the example of the correct answer.

Once the Button is clicked, the first lime of commands is activated – animation of ImageTrue, symbol ✅ (ImageTrue (Animator)) in Animator.Play. According to the animation, the picture is scaled up to normal sizes varies and scales down to invisible sizes. After the first animation is completed, the second line of commands is activated – the program refers to settings GameObject.SetActive of the object Lampa and displays (represents) it in the scene. Then, the third line of commands is activated – the AnimScrollViewClose is implemented to provide hiding of ScrollViewHL(Animator) to the top part of the screen.

The result of successful passing of all tests is the representation of electronic models in the correct symbols of the scheme (figure 11).

The last part in the application development is scene design based on the practical training. The purpose of this stage is: to show the sequence of the equipment connection in the simple electric circuit, as well as modelling of the lamp voltage, current and light intensity change in different positions of the rheostat slider.

The operation principle of the last part of the application is as follows: the observer sees the displayed electronic models of the electric circuit equipment placed on the table. There is a prompted button in the right top part of the screen advising what is performed at this step. By clicking the buttons, the red connecting wires to be connected to the relevant terminals of the equipment gradually appear. In case of repeated connection of the circuit, there will be an inscription on the button offering to close it. At this step, the current-controlled switch goes back to the horizontal position, and the slider will appear under the button. By moving the slider to the right, the rheostat slider will also move along the upper guide. At this,

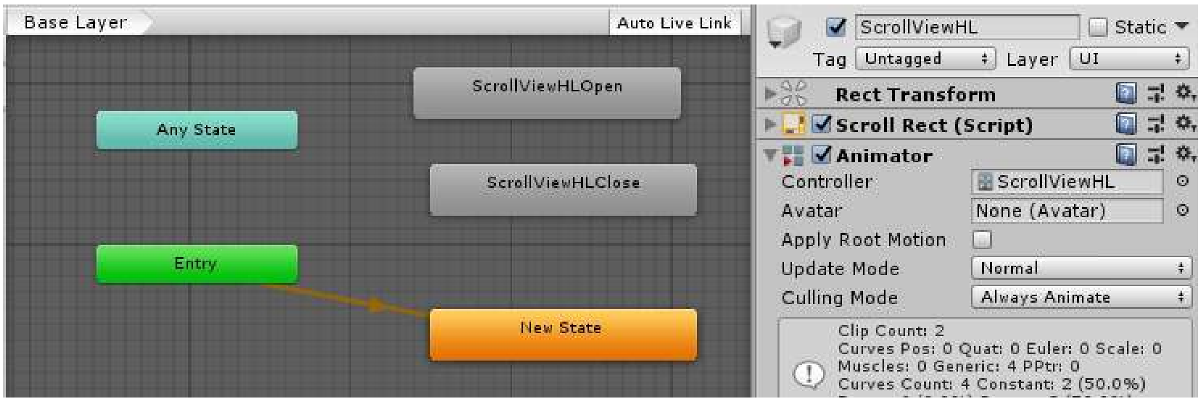

Figure 7: Implementation of displaying the ScrollView component.

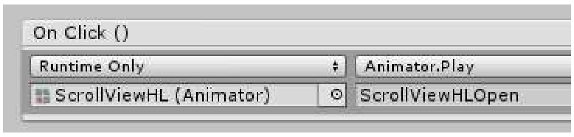

Figure 8: Setting the displaying button for the ScrollViewHL component.

the voltmeter and amperemeter pointers are deflected from their initial positions, and the light intensity will increase. The made electrical circuit of the program is shown in figure 12.

The development of the practical training scene is started by loading the electronic models of tables and components of the electric circuit. All the equipment is scaled up and placed as shown in figure 12. Connect the clamps of each device in series using the red connecting wires. By default, the wires are inactive, that is invisible. The Canvas component is added and set up. The information button is activated by the Button command that includes the display of the Panel tool with the instruction on the section operation. The "Back" button operates via the SceneManager script and forwards the user to the main menu. In the right part of the Canvas, using the Button command, the buttons for in-series connection of all elements of the diagram are added. The first button "Connect battery to lamp" is active and visible for the observer. Other buttons, such as "Connect voltmeter to lamp", "Connect lamp to amperemeter", "Connect amperemeter to rheostat", "Connect rheostat to switch", "Connect switch to battery" and "Close the circuit", are superimposed and inactive. The operation principle of the buttons is as follows: once the active button "Connect battery to lamp" clicked, the commands of On Click () are activated (figure 13).

The first line of commands refers to the settings GameObject.SetActive of the object Kabel1 (connecting wire from the battery to the lamp) and displays (represents) it in the scene. The second line of commands also refers to the settings GameObject.SetActive of the object ButtonLampa-Voltmeter only (the button "Connect voltmeter to lamp") and also represents it in the scene. According to the same principle, the last line of commands inactivates the button ButtonAcum-Lampa ("Connect battery to lamp"). In a similar way, other buttons for connection of the electric circuit with the connecting wires are set up.

The click set-up of the last button "Close the circuit" is shown in figure 14.

Once the Button is clicked, the first lime of commands is activated – animation SwitchClose of the object (Electric Knife switch (Animator)) in Animator.Play. According to the animation, the handle of the current-controlled switch rotates around the axle and closes the electric circuit.

The second line of commands refers to the settings GameObject.SetActive of the object Point Light (point light of the lamp) and makes it active. Therefore, now we can turn on, change the light intensity and turn off the light.

The third line of commands refers to the settings GameObject.SetActive of the object ButtonStart (the button "Close the circuit") and represents it in the scene.

In a similar way, the last line of commands activates the Slider.

At this development stage, nothing occurs when the Slider moves. For proper settings of the slider, the following tasks should be solved when it moves:

1. Synchronous movement of the rheostat slider.
2. Rotation of the voltmeter and amperemeter pointers to the required indications.
3. Change of the light intensity using the Point Light aids.

The movement of the rheostat slider when the Slider moves is implemented as follows. The slider

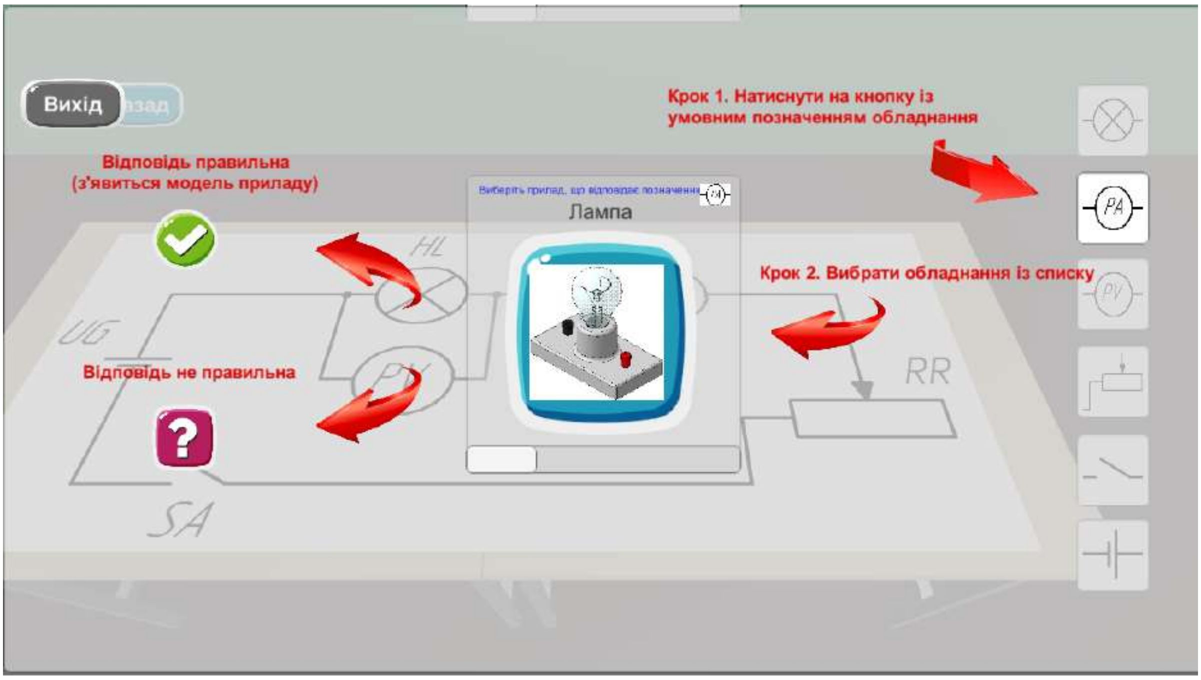

Figure 9: Operation scheme of the theory checks scene.

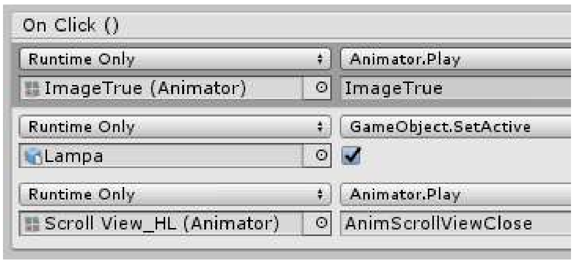

Figure 10: Button settings with correct answer.

consisting of two parts, a carriage and a contact, was taken from the electronic model of the rheostat assembly. The positions of these parts were set so that z axes were directed along the rheostat and the following script was written:

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class Karetka : MonoBehaviour
{
  public GameObject ReostatKaretka;
  public GameObject ReostatKontakt;

  public void Slider_Change(float
      newValue)  {
    Vector3 posKaretka =
      ReostatKaretka.transform.localPosition;
    posKaretka.z = newValue;
    ReostatKaretka.transform.localPosition =
      posKaretka;
    Vector3 posKontakt =
      ReostatKontakt.transform.localPosition;
    posKontakt.z = newValue;
    ReostatKontakt.transform.localPosition =
      posKontakt;
  }
}
```

Writing the scenario on movement of the rheostat slider is started by writing public class Karetka and introduction of two public GameObject – ReostatKaretka and ReostatKontakt. In the public method public void SliderChange(), the parameters are specified in the form of float data with the data name newValue. Local coordinates of the carriage of the rheostat slider ReostatKaretka.transform.localPosition are saved as the coordinates Vector3 named posKaretka. The object ReostatKaretka will move exclusively along the z axis, that is why this coordinate posKaretka.z has a new assigned data value newValue. The new coordinates for ReostatKaretka.transform.localPosition are saved as posKaretka. The similar line of the script is also written for the second part of the rheostat slider – the contact (ReostatKontakt). As the Slider is the Canvas object, the script is added to this component and the public objects ReostatKaretka and ReostatKontakt are assigned. In the settings Slider, section On Value Changed (Single) for the script Canvas (Karetka), the relevant func-

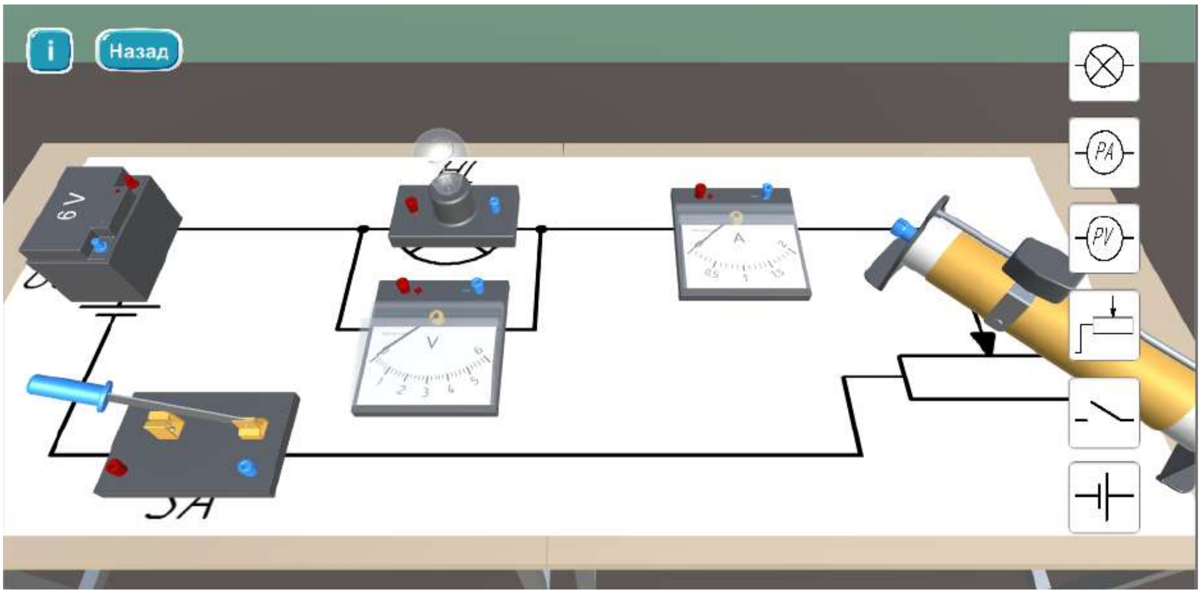

Figure 11: Successful theory checks results.

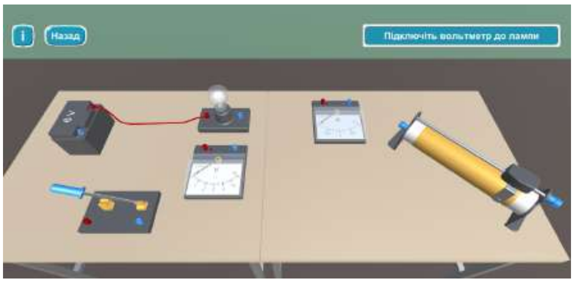

Figure 12: Operation of the practical training scene.

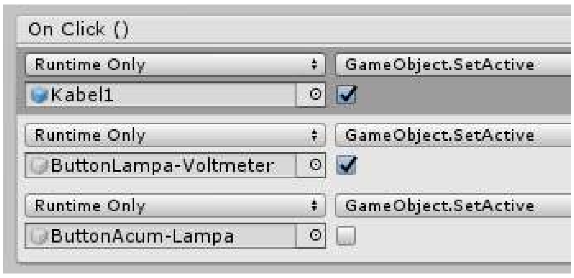

Figure 13: Button settings to connect the connecting wires to devices.

tion Karetka.SliderChange is selected Now, when the slider moves to the right, the rheostat slider will also change its position along the rheostat.

When the rheostat slider moves, the electric circuit resistance changes and the amperemeter and voltmeter pointers are deflected from their initial values. This effect can be implemented in the mobile app as follows. The electronic models of the amperemeter and voltmeter pointers are taken out of the assemblies and set in the required place of the scene. At this,

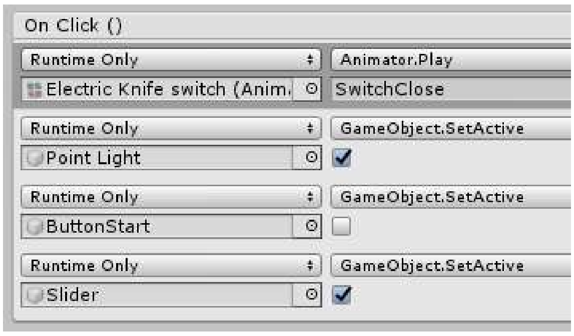

Figure 14: Button settings to close the electric circuit.

the centres of coordinates of each pointer go from the centers of the axes of rotation, and the axes match the axes of rotation. The pointers are rotated by the following script:

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class VoltAmmRotate : MonoBehaviour
{
  public GameObject Voltmeter;
  public GameObject Ammeter;
  float angleVolt;
  float angleAm;

  void Start() {
    angleVolt = -41f;
    angleAm = -41f;
  }

  public void Slider (float speed) {
    angleVolt = -41 - speed * 90 / 155;
```

```
    angleAm = -41 - speed * 60 / 155;
  }

  void Update () {
    Voltmeter.transform.rotation =
      Quaternion.Euler(0, angleVolt, 0);
    Ammeter.transform.rotation =
      Quaternion.Euler(0, angleAm, 0);
  }
}
```

Writing the scenario based on rotation of the amperemeter and voltmeter pointers at the specified angle is started by writing the public class VoltAmmRotate inheriting the basic class MonoBehaviour.

To upload the pointer models in the game engine, two public objects Voltmeter (for the voltmeter pointer model) and Ammeter (for the amperemeter pointer model) are written.

Two variables "float angleVolt and angleAm" that define the numerical value of pointer rotation are entered. In the method Start(), the coefficients of initial values of the pointer rotation that depend on the turn of the coordinate system of the pointers relative to the global coordinate system of the scene. In our case, they represent -41f. Therefore, the pointers in both cases will indicate zero values on the grade.

For slider operation, the method Slider() is written for which the parameters are specified in the form of float data with the data name "speed". In this method, the pointer angles of rotation will be calculated depending on the slider value. The formulas for calculation of the pointer angles of rotation are as follows: for voltmeter – angleVolt = -41 - speed * 90 / 155; for amperemeter – angleAm = -41 - speed * 60 / 155. These formulas were obtained through the experiment according to the data of the real electric circuit (figure 1).

To rotate any GameObject, the quaternion saving the Transform rotations in the space should be changed in the Transform properties. Turning the object at the specified angle is made using the Euler quaternion (Quaternion.Euler). In our case, the objects (the voltmeter and amperemeter pointers) turn around the Y axes only, that is the angles of rotation around the X and Z axes make 0 degrees. Therefore, the line of script for turning the voltmeter pointer appears to be as follows:

```
Voltmeter.transform.rotation =
  Quaternion.Euler(0, angleVolt, 0);
```

The similar line is also written for turning the amperemeter pointer:

```
Ammeter.transform.rotation =
  Quaternion.Euler(0, angleAm, 0);
```

Enter these two lines into the function Update(). Now, the voltmeter and amperemeter pointers will turn at the specified angle after each movement of the rheostat slider.

The last task on changing the light intensity while the rheostat slider is moving is implemented by the means of the Point Light object. The point light is an internal Unity3d object and its properties have already contained the light intensity parameters. Therefore, it is sufficient to link the light intensity to the Slider object. To do this, one more line to be performed is added in the settings Slider, section On Value Changed (Single), and then the Point Light is added where the Light.intensity is selected.

Hence, when the Slider moves, the rheostat slider is moving in the proper direction, the voltmeter and amperemeter pointers are deflected at the specified angle and indicate the effective voltage and current values, and the light intensity also changes depending on the indicators.

According to the above method, the last scene with information about the mobile app authors is created, and the installation file for Android is compiled.

The operation and main options of the mobile app can be seen in the demo video "Augmented reality program to study the simplest electric circuit" (YouTube, 2020).

The next stage in the development of any program is testing. The developed mobile app was tested on the following Android-based mobile devices:

1. Samsung Galaxy A5 A520F – Android 8.0.0; 5.2" screen; 1920x1080 pixel; 8-core processor Exynos 7880 Octa; 16MP cam; 3 GB RAM
2. Xiaomi Redmi Note 4x – Android 7.0; 5.5" screen; 1920x1080 pixel; 8-core processor Qualcomm Snapdragon 625; 13MP cam; 2 GB RAM=
3. Xiaomi Redmi 4x – Android 7.1.2; 5.0" screen; 1280x720 pixel; 8-core processor Qualcomm Snapdragon 435; 13MP cam; 2 GB RAM
4. Lenovo S8 A7600 – Android 5.0; 5.3" screen; 1280x720 pixel; 8-core processor MT6592M; 13MP cam; 1 GB RAM
5. Lenovo A6010 Pro – Android 5.0; 5.0" screen; 1280x720 pixel; 4-core processor Cortex-A53; 13MP cam; 2 GB RAM

The correct representation of all scenes and their components, models movement and rotation, proper button activation by screen touching should be tested.

According to the test results, it can be concluded that the program operates correctly on the phones both based on Android 5.0, and on the newer systems irrespective of the processor type, screen matrix and memory capacity.

Therefore, the mobile app "Augmented reality program to study the simplest electric circuit" developed by us reads and recognizes the electric circuit marker and displays the main menu on the mobile device screen. At this, the virtual object is correctly located relative to the marker, and once the buttons of sections clicked, the relevant scenes for theoretical training, assessment of received knowledge and acquired practical skills for making the simple electric circuit are loaded.

The described mobile app development method makes it possible to implement a number of challenges of the modern educational process for comprehensive learning. It is possible to learn the electronic models design after studying such disciplines as "Engineering Graphics" or "Descriptive Geometry, Engineering and Computer Graphics". "Advanced Mathematics" is the basis for script writing. It is possible to learn reading the electric circuits and make the electric circuits when studying the course "Physics" (Gorda et al., 2018). This Instruction can be the foundation for successful future professional activity of the students of technical specialties in the electronic model development; promote learning motivation and individual work efficiency by making the learning process attention-getting and interesting, especially after development of own learning aid of new generation; and the mobile app provides the students with the opportunity to master practical skills and research experience by using own gadget.

3 CONCLUSIONS AND PERSPECTIVES OF FURTHER RESEARCH

The literature review has shown the wide use of the AR technology both in social spheres of the human activity, and during study. The scientists all over the world give the research results where the AR improves the performance of students in humanitarian and technical disciplines. It appears that the most common areas of use of the AR technology are mathematics, chemistry, physics, ecology, astronomy, engineering graphics, history, etc.

Many researches show the reasonability of using the electric models as learning aids, as a man equally perceives physical and electronic models. However, the electronic models have a number of advantages in contrast to the physical models, thus proving the reasonability of description of methodology and creation of applications for mobile devices using the AR technology.

The analysis performed for the 3D modelling programs has given an opportunity to substantiate the choice of digital product with open code. The main steps of installation of the game engine and additional components, including the Vuforia Augmented Reality platform, have been demonstrated. The stages of the scene development have been provided. Writing scenarios (scripts) with detailed decoding of each line has been particularly focused on. The ready program has been tested by students on mobile phones with different specifications while preparing for classroom learning in physics on the topic of the simple electric circuit. The demo video demonstrating the program operation and main features has been also created. The demonstrated experience in the development of the augmented reality program in physics will be useful for teachers in writing own applications.

This article describes the methodology of development of the mobile app using the AR technology only on the one topic of physics. In the future, we are going to create a full-pledged electronic complex (virtual physics laboratory) to include the theoretical part, tests and exercises for modelling physical phenomena and experiments.

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Possibilities of using the Game Simulator Software Inc in the Training of Future Software Engineers

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Abstract: The article presents the possibilities of use game simulator Software Inc to form a sustainable professional competence of a software engineering specialist: the ability to: apply knowledge in practical situations; communicate in a foreign language; work in a team; act based on ethical considerations; commitment to preserving the environment; evaluate and take into account economic, social, technological and environmental factors affecting the sphere of professional activity; for lifelong learning. The use game simulators, in the educational process, allows to improve the quality of educational material and to enhance the educational effects from the use of innovative pedagogical programs and methods, as it gives teachers additional opportunities for constructing individual educational trajectories of students. In the process of research, students gain knowledge, skills of the future IT specialist and competences of the legal protection of the results of intellectual activity, technological audit, marketing, product realization in the market of innovations. There are many ways in which a company can achieve a dominant position in the industry. For example, the staff of a virtual company can work on developing editorial software for designers, business tools for offices, video games for the console, and even, if time and skill level allows, they can develop their operating system. So in the game simulator Software Inc students are invited to build and design office buildings for optimal working conditions of their own software development company.

1 INTRODUCTION

More and more educational institutions are introducing new teaching methods, which result in the use of engineering students, in particular, majoring in software engineering, to deal with real professional situations in the learning process (Liu et al., 2011; Mtsweni et al., 2016).

The use of modern ICT, including game simulators, in the educational process (Demirbilek and Koç, 2019), allows to improve the quality of educational material and to enhance the educational effects from the use of innovative pedagogical programs and methods, as it gives teachers additional opportunities for constructing individual educational trajectories of students. The use of ICT allows for a differentiated approach to students with different levels of readiness to study.

A feature of any software engineer is the need to understand the related subject area for which the software is being developed (Striuk, 2018). An important condition for the preparation of a highly qualified spe-

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cialist is the independent fulfillment by the student of scientific research, the generation, and implementation of his idea into a finished commercial product. In the process of research, students gain knowledge and skills of the future IT specialist among with the competences of the legal protection of the results of intellectual activity, technological audit, marketing, product realization in the market of innovations. Note that when the real-world practice is impossible for students, game simulators that simulate real software development processes are an alternative.

The importance and necessity of introduction of information and communication technologies (ICT), including game simulators, in training, are substantiated in (Ahmed et al., 2013; Atal and Sureka, 2015; Baker et al., 2003; Pant and Baroudi, 2008; Dantas et al., 2004; Karunasekera and Bedse, 2007; Hodges and Burchell, 2003; Calderón and Ruiz, 2014; Caulfield et al., 2011; Clarke and O'Connor, 2012; Dantas et al., 2004; Emam and Koru, 2008; Purna Sudhakar et al., 2011; Jazayeri, 2004; Noudoostbeni et al., 2009; Navarro, 2006; Sauvé et al., 2005). ICTs are part of every area of human activity and have a positive impact on education, as they open up opportunities for the introduction of completely new teaching and learning methods.

A significant contribution to the theory of educational games was made in (Elkonin, 1999; Klopfer, 2008; Michael and Chen, 2005; Vygotsky, 1962). At the same time, game technologies of teaching and use of interactive games in high school were investigated in (Alkan and Mertol, 2019; Al-Tarawneh, 2016; Buzko et al., 2018; Demirbilek and Koç, 2019; Gunter et al., 2008; Jackson and McNamara, 2017; Vieira et al., 2019; Tokarieva et al., 2019). However, the question of the use of game simulators in the training of future software engineers remains poorly understood.

2 RESULTS

Game simulators are interactive programs that fully or partially simulate certain real processes or systems that capture and motivate students through fun and interesting game experiences, where students can perform different roles in a variety of realistic circumstances and are used in the educational process when the real practice is impossible or inaccessible.

Software Inc is a game simulator that allows students to try their hand at running a software development company.

There are many ways in which a company can achieve a dominant position in the industry. For example, the staff of a virtual company can work on developing editorial software for designers, business tools for offices, video games for the console, and even, if time and skill level allows, they can develop their operating system.

Selling these products and complicating the tools used in the development process (for example, the transition from the command line to the graphical interface, from 2D graphics to 3D graphics) will contribute to the growth and development of the company, but to keep up with competitors, the user it is necessary to constantly update the technical support within the company.

So in the game simulator Software Inc students are invited to build and design office buildings for optimal working conditions of their own software development company. The game simulator allows you to build, provide, and maintain virtual office buildings up to ten floors high and expand workspaces in a large virtual area of the game simulator.

In the process of game simulation, future software engineers need to hire employees for their research, development, production, and maintenance of quality software, as it is necessary for the successful conduct of competitive activities of their virtual company (figure 1).

Students also face the need to manage and train their employees so that they are experienced and satisfied with their work. The attention of future software engineers to the needs, requirements, competencies, and specializations of employees, as well as their compatibility within teams is very important for the successful completion of the game simulation.

During the game simulation, students can also delegate certain important tasks (such as managing the software development process or human resource management) to team leaders within their company.

The main task of the game simulator Software Inc is to set up the process of creating their software products and franchises in a virtual company, setting up the process of selling software, concluding agreements and performing contracts, as well as obtaining patents for developed software products.

In the process of game simulation, students need to make decisions, for example, what software to develop (figure 2), how to configure their servers for software, how to manage software version control systems, and even whether to start their online store.

Players need to monitor the financial condition of the company (figure 3) because the company will be considered successful when its profits reach $ 50,000 or double the amount from which the game simulation began.

To start the game you need to press the "New

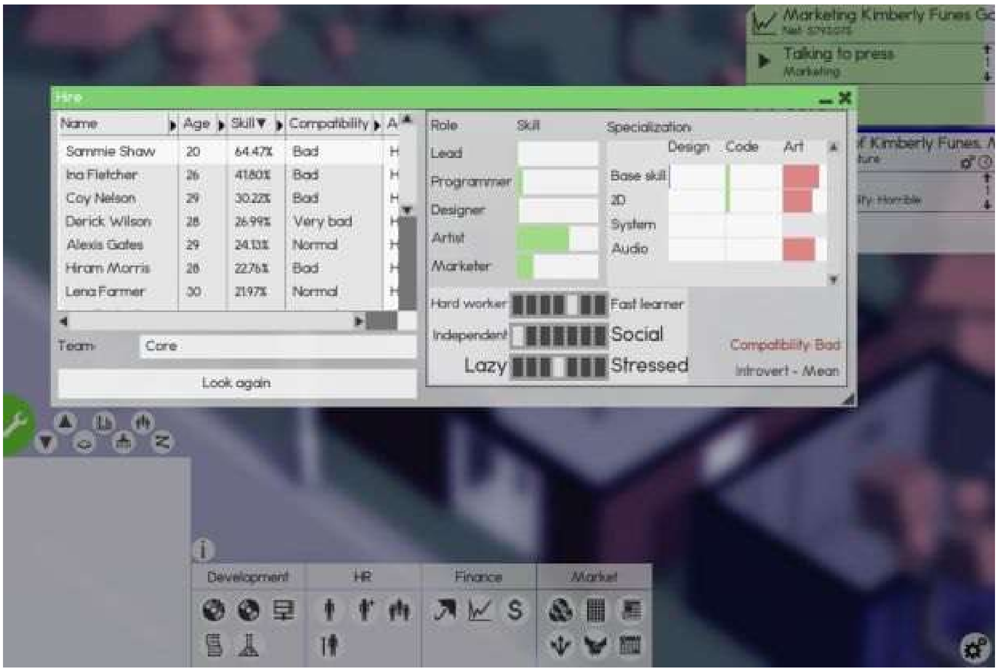

Figure 1: Dialog for selecting employees in the game simulator Software Inc.

Figure 2: Defining software requirements in the game simulator Software Inc.

Game" button, then the corresponding screen, shown in figure 4.

In the first stages, students should use a manual to provide detailed information about the gameplay and the various individual stages of the game. Beginners are encouraged to choose Optimism and Generosity as the main features when creating a company founder, without necessarily changing the settings of the sliders located on the left in the user interface.

In the panel on the right, you need to increase the startup capital of the company to \$ 20,000 or move the slider one mark if the game is in a different currency (the currency can be changed in the options menu). Set to default 1980 as the year the company

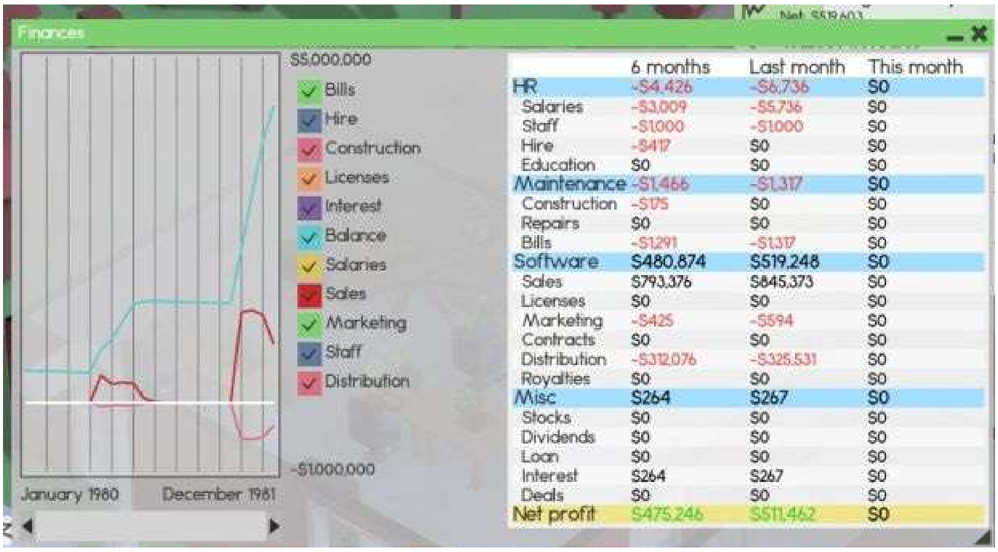

Figure 3: Indicators of the financial condition of the virtual company in the game simulator Software Inc.

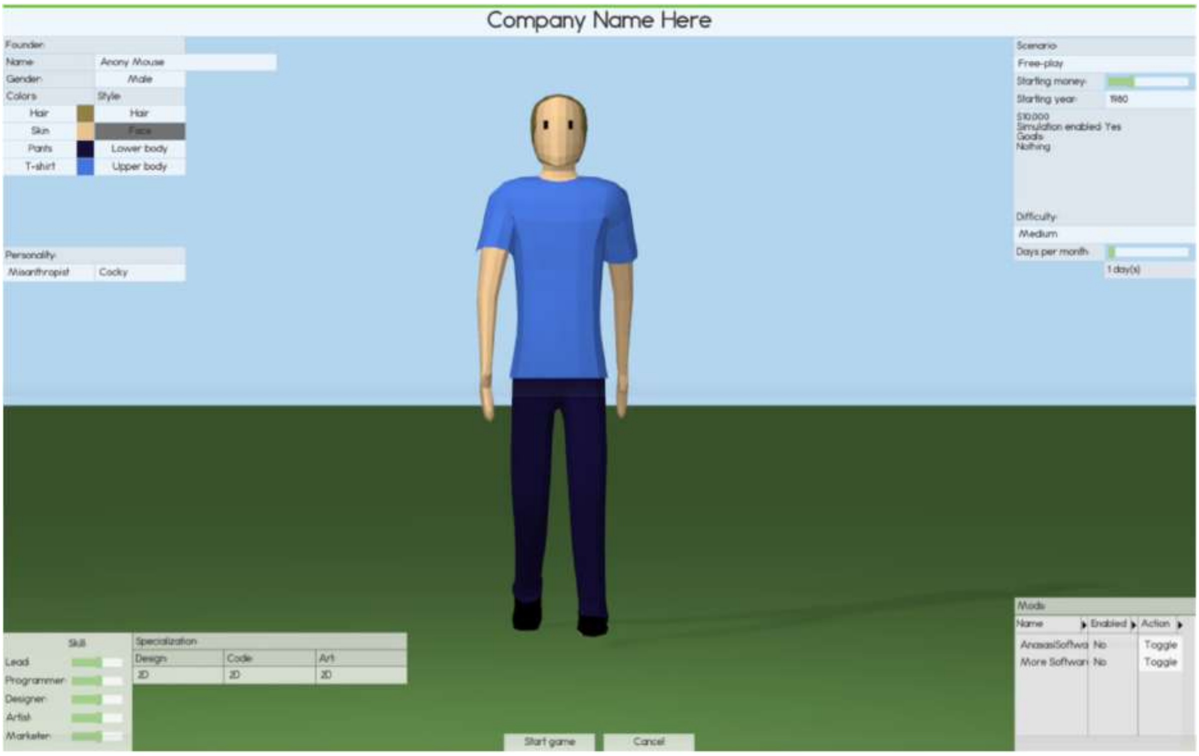

Figure 4: Starting a game simulation in Software Inc.

was founded, there is no need to change, but at the stage of getting acquainted with the game the difficulty level must be set to “Easy”.

The Days per month parameter sets the number of days in a month. By default, it is set to 1 day, meaning one game day will count as a month. With this setting, you can change the speed of the game (most of them set 4 days, but first you need to set the value to 1 or 2 days).

After that, the student needs to change the founding person’s settings and choose a name for their company, such as “SpaceTech” or “Aperture Cake Production”, after which the students will see the next window (figure 5).

You can move the instruction box around the screen and resize it. You have to press the “Continue”

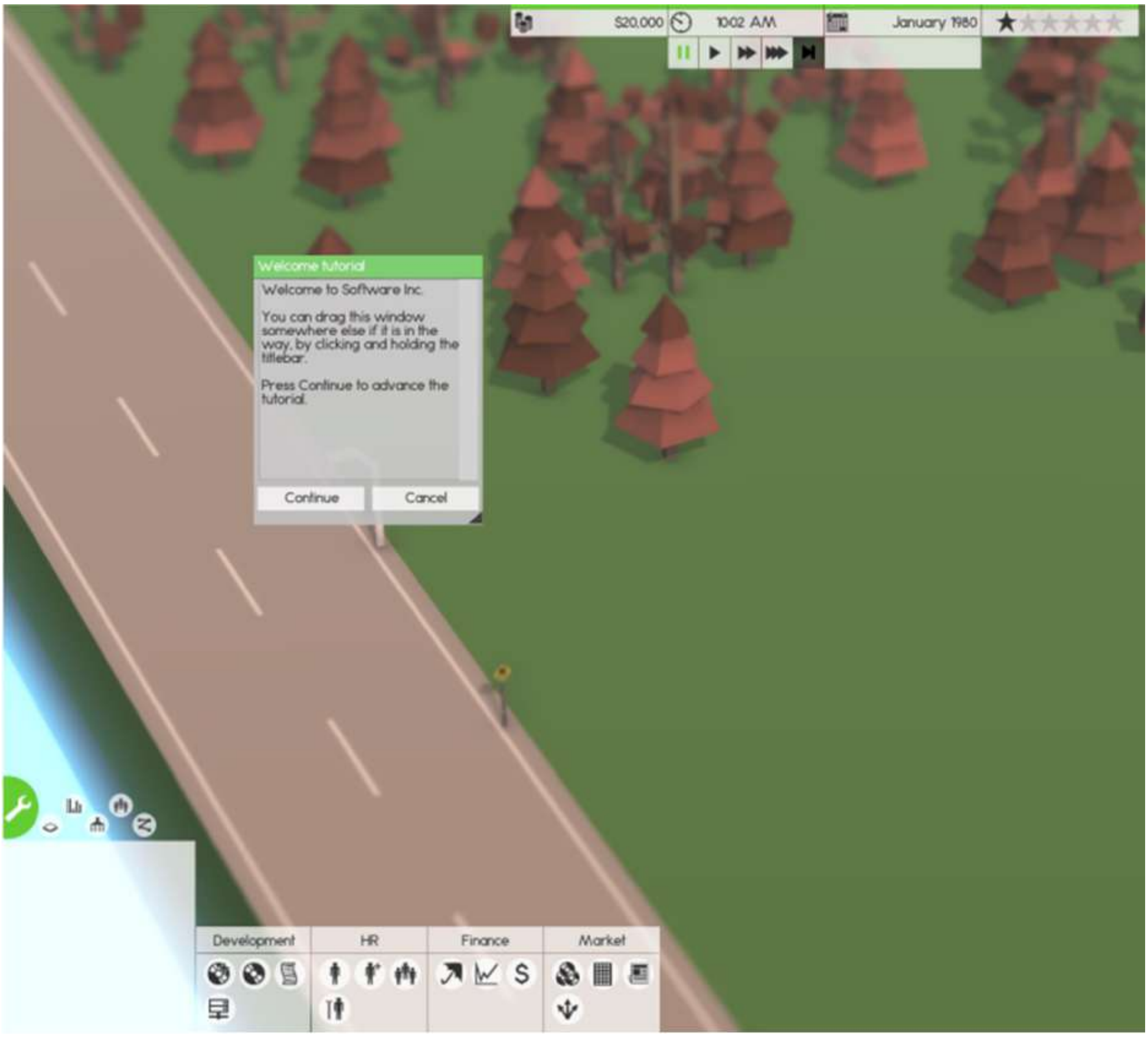

Figure 5: Welcome dialog in Software Inc.

button to flip through the manual. To start creating the premises of a future virtual company for a student, it is necessary to go into construction mode by clicking on the green button with the image of a wrench on the user interface.

Game Simulator Software Inc offers three build modes: "Construct" – construction of rooms, installation of windows and doors; "Furnish" – room furniture, choice of tables, chairs, coffee machine; "Roads" – road construction, parking, but initially this mode is not used.

Once enabled, the student must first build a small room for the virtual company. To do this, you need to use the Room Builder tool in the Construct mode menu. The initial size of the first room should be approximately 5x5 to accommodate the table and chair for the founder of the company.

To make the room light enough, you must select the windows and doors in the Construct mode menu and install them in the room.

Then students have to go into Furnish mode and have a desk, chair, and computer installed in the room. Use the Shift + left mouse button to set multiple items at once. Chairs will automatically be installed near the tables they are closest to, but you may need to turn your computer over.

Students need to click on and hold the computer, turning it in the required direction.

After that, the room will look something like this (figure 6).

Once the room has been created, the founder of the company can start working there. After reading the instructions, you must press the Tab key to exit the build mode. The process of making money and

Figure 6: A room built-in game simulator Software Inc.

working on contracts.

The first way that allows companies to make money is to work on contracts. Contracts are projects that are offered to companies for execution, and each of them has its requirements.

To find a contract, the participant must go to the “Development” menu by clicking the button with the image of a piece of paper (A). Then a pop-up window will appear on the screen (figure 7).

Players need to sort the list by “Months” (B) to ensure that contracts that require the least number of months are at the top of the list. Typically, contracts with 1 or 2 (C) contracts will have a performance period of 1 or 2 months. The company does not receive big profits for working on such contracts, but in the beginning, it is a great source of financial income.

Regarding the quality of contract work, students must set the value to “Bad” or “Horrible” (D), which allows the initial stages not to take quality but quantity.

Students need to find a contract for their virtual company with a minimum work requirement for a team of 1 or 2 people for a maximum of two months and click the ”Accept Work” button.

After the participants have selected a contract for their company, a project management pop-up window (A) will appear to the right in the user interface (figure 8). There are 4 stages of project implementation. The first stage is the development of the design. The product design specified in the contract is developed by the virtual company designer(s).

When pointing the mouse at the project management window, students can see the progress scale of a specific job by a company employee (B). The task is considered completed when the scale reaches its maximum value. However, students need to be careful and not delay the contracting process at the design development stage so as not to waste the time allotted for the contract.

Players must then click on the “Develop” (C) button in the project management window to proceed to the next stage – “Alpha”. At this stage, the software engineers create the product according to the design developed by the designer in the first stage. Students can monitor the completion of the assignment using the progress bar. When the task is completed, you must click on the “Promote” button to proceed to the next step.

The next stage is called “Delay” and is only an intermediate stage, which lasts a certain amount of time depending on the skill level of the company’s employees. The higher the skill level of the employees, the less time the Delay stage takes.

The project then proceeds to the “Beta” stage,

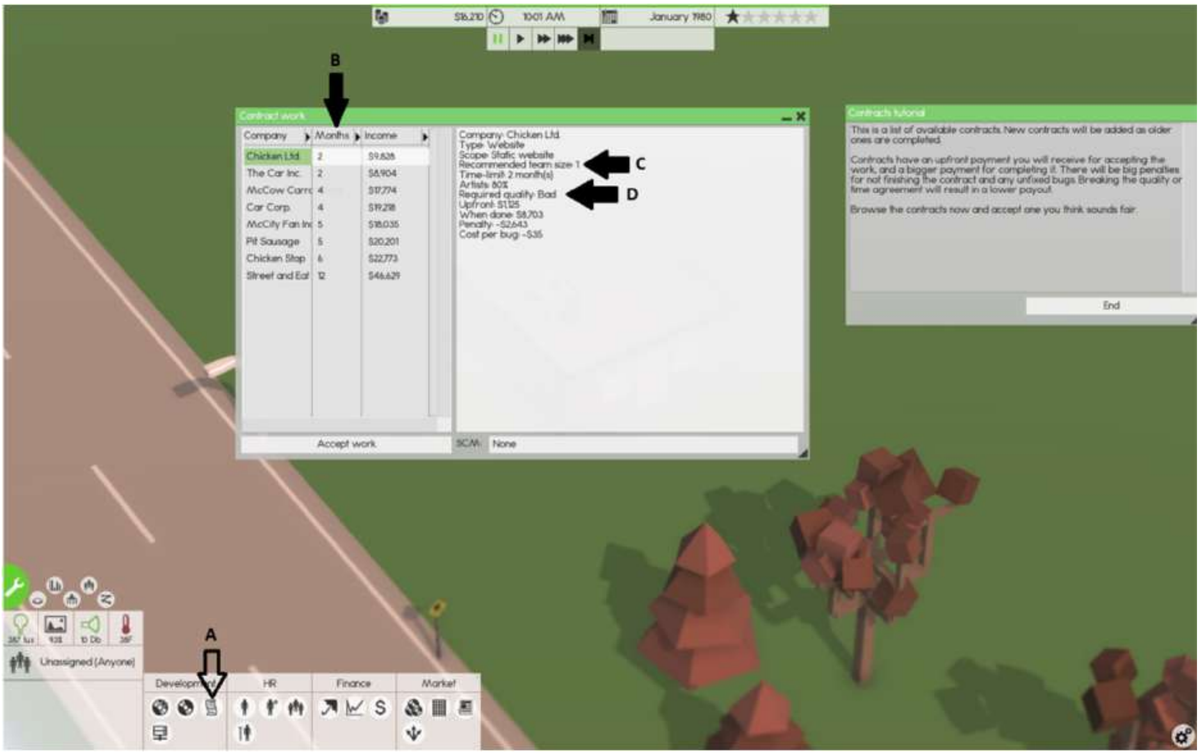

Figure 7: Software search contract simulator popup window.

Figure 8: The project management popup in the game simulator Software Inc.

which is to test and prepare for the product release. The company may release a product that is not ready for completion, but it is important to remember that the presence of errors and defects in the product will adversely affect its sales and contract payments.

When building premises, students need to remember that employees are first and foremost people who have basic needs (want to eat, go to the restroom, drink coffee, prefer quiet, comfortable rooms with sufficient lighting, comfortable air temperature, and a comfortable environment). Therefore, you should build a facility that addresses all these needs, and do not forget to build small facilities for restrooms and rest areas.

Make sure you also have a fridge and coffee table in the lounge. Windows, lighting, and doors between rooms are required. It is important to keep in mind that indoor plants will have a positive effect on employee productivity and mood. Elements such as heat radiators and ventilation in the main room are also very important as they provide comfortable air temperatures.

After the company has reached a certain level of development, students need to hire new employees in the team. When looking for a new employee, you first need to answer two questions:

1. In what position to open a vacancy?
   - team lead;
   - designer;
   - creative manager;
   - marketer.
2. How much time and resources can be spent on finding a new employee?

Then more time is spent on searching, then more applications from candidates will be considered. At the same time, it is necessary to consider the insurance policy of the company. Having a solid insurance fund will be an attractive factor for skilled workers. Therefore, every time after the completion of contract work and products, students need to invest in improving the insurance fund to attract highly qualified employees to the company (Vakaliuk et al., 2020).

After the list of candidates is created, you can go to the interviewing stage, during which you need to determine who should be hired and who should be better off. Keep in mind that you need to hire those who can be part of the team, as this will have a positive effect on the performance of the company and help you get things done faster.

The following is an example of a candidate whose compatibility with an existing team is low (figure 9).

At the same time, there is a candidate whose compatibility with the team is sufficient (figure 10).

By finding a candidate with sufficient compatibility with the development team, as well as sufficient professional performance, players can hire a suitable candidate for their development team. They can then focus on managing software development or, if they see fit, continue to hire employees.

In the process of using game simulators in the educational process, the following methods are used:

1. *Project method.* This game simulator is based on simulation of software development projects, where future software engineers can directly feel like a participant in a realistic software development project and directly influence its progress, as well as the success of its implementation and completion.

   As the player manages the process of completing the software development project, he can also hire and fire employees, give them tasks, monitor their progress, and buy tools, and more.

   A great advantage of project activities is the skills that students acquire, namely:
   - plan their work, pre-calculating the possible results;
   - use many sources of knowledge and data;
   - independently collect and accumulate material;
   - analyze, compare facts, argue their point of view;
   - make a decision;
   - establish social contacts (distribute responsibilities, interact with each other);
   - to create a “final product” – a material carrier of project activities (report, abstract, film, calendar, magazine, prospectus, script).
2. *Adaptive learning*. With the help of a game simulator, a so-called “examination cycle” is created, ie game simulations will present students with similar types of problems until the necessary professional soft competencies are formed. Then game simulations create new problems for students, which can no longer be solved only with the help of previously formed competence. This forces students to rethink the existing professional soft competencies and acquired experience, knowledge, skills, and abilities and to form new competencies and integrate them with the previously formed ones.
3. *Modeling situations*. The game simulator simulates a variety of professional situations: project development with restrictions on time, budget, and quality of the final product; the need to hire, train and manage a software development team; situations where timely communication with other

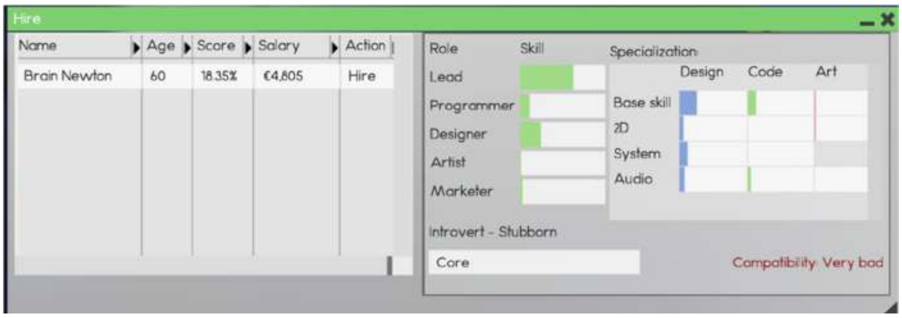

Figure 9: Example of showing poor candidate compatibility with an existing team in a game simulator Software Inc.

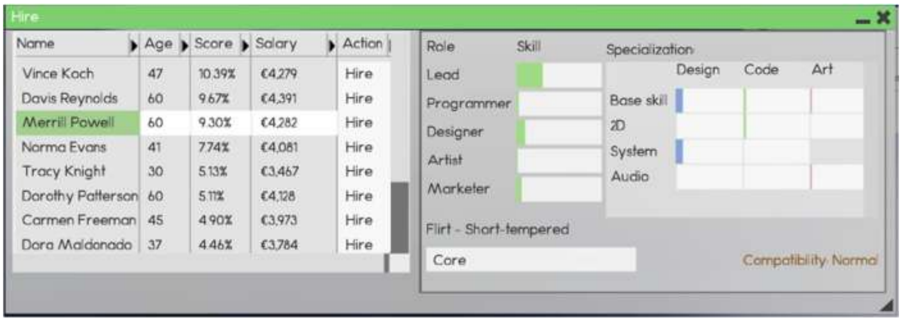

Figure 10: An example of showing good candidate compatibility with an existing team in a simulator Software Inc.

team members or clients is required; professional and ethical dilemmas; situations of the need to establish and maintain appropriate processes of marketing, sales and innovation research. Also important is the exciting gameplay provided by the game techniques and the dynamics of game simulations. This captures and sharpens students' interest, making the learning process more memorable and therefore more efficient.

During the game simulation in the game simulator Software Inc are formed as follows competencies aimed at forming a stable professional competence of a specialist in software engineering (as defined in (Semerikov et al., 2020)):

- ability to apply knowledge in practical situations;
- ability to communicate in a foreign language;
- ability to work in a team;
- ability to act based on ethical considerations;
- commitment to preserving the environment;
- ability to evaluate and take into account economic, social, technological, and environmental factors affecting the sphere of professional activity;
- the ability for lifelong learning.

After all, in the process of passing the simulation, students need to work with their staff to achieve common goals. To complete game simulations, students need to identify, organize, and maintain mutually beneficial relationships not only within the team but also outside it. Another important factor is the fact that this simulator is in English, and therefore students develop foreign language communication skills.

The comparative research method allowed to trace the positive dynamics of the levels of formation of professional competencies during the application of this game simulator in the educational process (figure 11). Statistical analysis was performed using the Pearson test, in which students were divided into two groups, and accordingly established the approximate equality of the level of formed competencies of students in both groups at the initial stage and the difference at the final. As a result, the results show the positive dynamics and, accordingly, the effectiveness of the proposed game simulator in the learning process.

3 CONCLUSIONS

During the game simulator Software Inc are formed as follows competencies aimed at forming a stable professional competence of a specialist in software engineering: the ability to: apply knowledge in practical situations; communicate in a foreign language; work in a team; act based on ethical considerations; commitment to preserving the environment; evaluate and

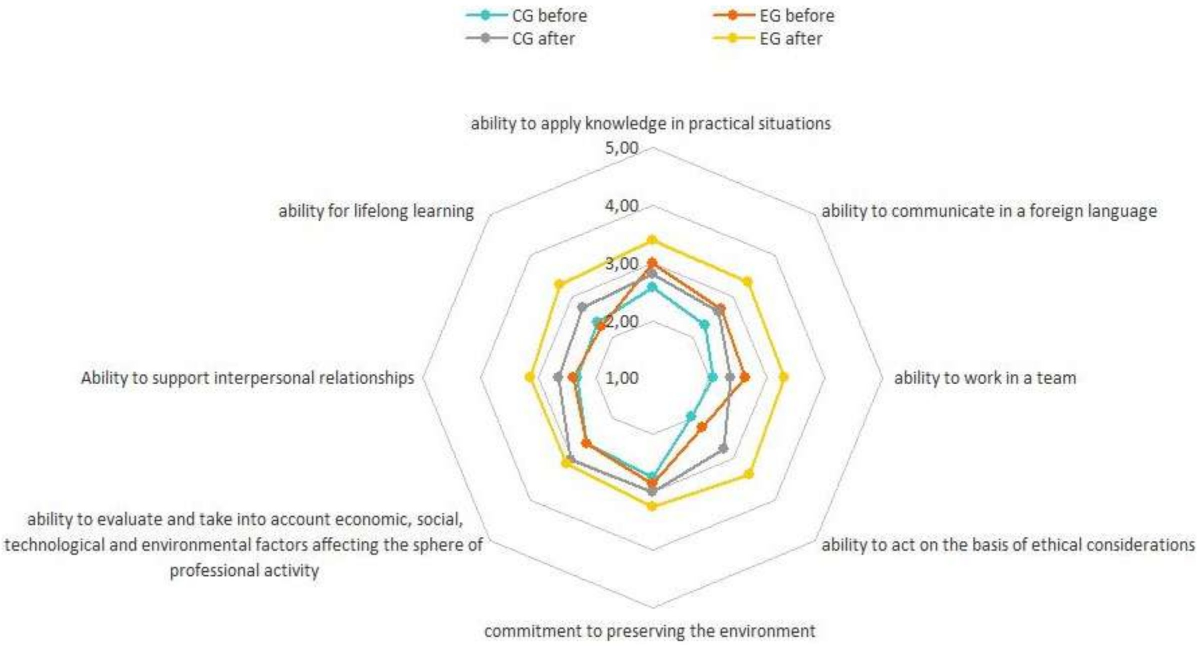

Figure 11: The average assessment of the levels of professional competencies of students in CG and EG at the beginning and end of the experiment.

take into account economic, social, technological and environmental factors affecting the sphere of professional activity; for lifelong learning. This has been confirmed experimentally. Prospects for further research may be a set of non-use of several simulators and their impact on the development of professional competencies of future software engineers.

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Digital Technology Implementation for Students' Involvement Base on 3D Quest Game for Career Guidance and Estimating Students' Digital Competences

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Keywords: Virtual Reality, Quest Game, 3D Model, Career Guidance, Computer Science, Higher Education.

Abstract: This paper reveals the process of creating a career guidance 3D quest game for applicants who aim to apply for IT departments. The game is based on a 3D model of the computer science and information technologies department in the National Aerospace University "Kharkiv Aviation Institute". The quest challenges aim to assess the digital competency level of the applicants and first-year students. The paper features leveraged the theoretical background, software tools, development stages, implementation challenges, and the gaming application scenario. The game scenario provides for a virtual tour around a department of the 3D university. As far as the game replicates the real-life objects, applicants can see the department's equipment and class-rooms. For the gaming application development, the team utilized C# and C++, Unity 3D, and Source Engine. For object modeling, we leveraged Hammer Editor, Agisoft PhotoScan Pro, and the photogrammetry technology that allowed for realistic gameplay. Players are offered various formats of assessment of digital competencies based on the Digital Competence Framework for Citizens (DigComp 2.1): test task, puzzle, assembling a computer, and setting up an IT-specialist workplace. The experiment conducted at the online open house day 2020 proved the 3D quest game efficiency. The applicants estimated a 3D quest, as more up-to-date and attractive engagement. According to the results of the 3D quest, applicants demonstrated an average level of digital competence with some certain items difficulties at 0.5. Several psychometric item characteristics were analyzed in detail that would allow us to improve the item's quality.

1 INTRODUCTION

Augmented and virtual reality (AR and VR) are popular tools to introduce any concept more attractively or interactively. Utilizing AR and VR are most common for medicine, geospatial applications, manufacturing, tourism, and cultural heritage (Frontoni et al., 2019; Lavrentieva et al., 2020) .

The choice of technology and how to apply it, in particular in the higher education field, depends on the research subject, resourcing, and the teachers' and students' competency. The experimental research on digital competency proved: the readiness level to start digital education is high enough (Kuzminska et al., 2018). Thus, arises the question of creating virtual objects and a methodology on how to utilize them in the educational process. For instance, the paper by Thürkow et al. (Thürkow et al., 2005) explains the experience of utilizing landscapes and excursions as a means of training in geography. Also, the research by Patiar et al. (Patiar et al., 2017) describes the students' experience with an innovative virtual field trip around hotels.

Among the virtual objects' representation formats, gamification gains special importance, since it provides for additional motivation and active participation of the student (Tokarieva et al., 2019; Vlachopoulos and Makri, 2017).

The training games include quests, arcades, simulator games, virtual simulators, and interactive

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courses (Demirbilek and Koç, 2019; Kompaniets et al., 2019; Vakaliuk et al., 2020). We considered quests to be the most interesting genre among the above mentioned (Barab et al., 2005; Shepiliev et al., 2021). Villagrasa and Duran (Villagrasa and Duran, 2013) analyses the effectiveness of utilizing gamification to motivate Spanish students into studying with a 3D visualization as support for Problem-Based Learning (PBL) and Quest-Based Learning (QBL) to students' collaborative work. Rankin et al. (Rankin et al., 2006) investigated the cognitive and motivational influence of 3D games on studying the second language and creating a digital learning environment for second language acquisition (SLA). At the same time, the transition to e-learning requires additional research on approaches not only for designing virtual objects and digital educational environments to stimulate students' motivation to study (Katsko and Moiseienko, 2018; Ma et al., 2012), but also to assess students' knowledge and confidence acquired competencies (Kuzminska et al., 2018).

The specifics of the paper-based versus computer-based testing results application and comparison became extremely relevant during the COVID-19 pandemic when the majority of students switched to distance learning. In particular, this problem stands out for the high schools (Özalp-Yaman and Çağıltay, 2010; Ita et al., 2014; Garas and Hassan, 2018).

According to previous studies, in particular, Özalp-Yaman and Çağıltay (Özalp-Yaman and Çağıltay, 2010), students' performance does not depend on the testing method – the results showed similar scores for both computer-based and paper-based testing. However, the researchers consider the digital educational environment and the computer-based testing (or e-testing) environment improvements to be perspective. Whereas, the students claim that e-testing has several limitations, such as lack of communication with the teacher, inability to determine the order of test questions, and error analysis sessions. Thus, despite the attractiveness of digital technology, students prefer paper-based testing.

The research on the relationship between students' confidence and self-efficacy is also very relevant during e-learning (Blanco et al., 2020). Students' motivation, cognitive activity, and the desire for self-regulated learning and self-improvement influence their self-efficacy. The degree to which students' self-efficacy skills are acquired and improved, in particular during monitoring and final assessment through testing, varies depending on students' characteristics, and factors related to the testing process and educational environment.

In our opinion, it is possible to make electronic testing simpler for students by combining gamification, case technology, and virtual reality. However, the equally important task is to determine the item test structure that would allow for objectively assessing the knowledge and skills acquired by students.

De Carvalho Filho (de Carvalho Filho, 2009) studied the influence of metacognitive skills and types of tests on students' results, confidence in their judgments, and the accuracy of these judgments. In particular, the study concentrated on how students with different cognitive and metacognitive skills processed four types of test questions (multiple-choice, short answer, single-choice: "yes" or "no", essay tests). The results proved it is impractical to use the same type of test question sets. This claim corresponds to the recommendations of the DigComp 2.1 framework for assessing students' digital competencies, performed by the authors in previous studies (Kuzminska et al., 2018, 2019).

However, due to COVID-19, the question of finding a way to conduct career guidance and advertising campaigns in a remote format became relevant.

Since the career guidance of the future specialist is on-trend today, universities suggest many formats of how students can get to know the university, and use various forms of online communication with applicants. The career guidance is now on-demand, and recommendations on how to pursue a career path, in particular how to prepare for external independent evaluation, or recommendations on informal education, can be beneficial in helping students to manage their education and career. This can influence the students' consciousness and help to improve the educational system's effectiveness, as well as the equation of demand and supply at the labor market (OECD, 2017).

The research *aims* to create a career guidance 3D quest game to estimate the students' competency, and as well, to attract more applicants, and increase the visibility of the department.

2 THE PROJECT IMPLEMENTATION

2.1 Problem Definition

- *Target audience*:
  - applicants: assessing the digital competency level to understand if the applicant is ready to enter the computer science department, career guidance, department promotion;

- first-year students: assessing the digital competency level to adjust the program of education, introducing the department' activities, career guidance;
- developers of the gamified applications: specification to the technical implementation of the gamified application "Passcode".

• *The technical implementation defines the following scope of tasks*:
  - free movement, acting, and selecting players according to the game scenario;
  - analyzing data on the users' actions;
  - assessing users' actions, demonstrating the users' progress;
  - the current score showing and saving feature;
  - utilizing a database to simulate challenges.

• *Expected results of using the gamified application "Passcode"*:
  - enlarging the target audience to provide for career guidance activities;
  - boosting the applicants' motivation to study and providing them with career guidance;
  - assessing digital competency of intendant IT-specialists for further adjusting the educational plans to suit their skills and level of knowledge;
  - assisting in the development of gamified applications that utilize 3D models.

• *Summarizing the numerous study results, we can highlight the main points we considered when formulating the task to develop the gamified application 3D quest "Passcode"*:
  - the impact values on the test results for paper and computer testing are usually statistically insignificant ($p > 0.05$). Thus, there is no significant difference between these approaches, and computer-based testing can grant for objective assessment;
  - to determine the categories of digital competence assessment, we utilized the framework of digital competence of citizens DigComp 2.1, recommended as a system that "takes into account" both cognitive and metacognitive skills of respondents. However, the content of the items test was prepared considering the specifics of the training for future IT professionals;
  - developing the testing environment and building a test in form of a quest with the appropriate logic, tasks, prompts, and voice guidance can reduce participants' concerns about their performance and help receive accurate assessment results;
  - the 3D quest game that is based upon the 3D model of the computer science and information technologies department at the National Aerospace University "Kharkiv Aviation Institute" will motivate future students to get acquainted with the university and help them not to feel like being examined or controlled.

2.2 Means of Technical Implementation

To develop our 3D application, we leveraged Unity as the main engine (Finnegan, 2015; Haranin and Moiseienko, 2018). Unity is a cross-platform tool for developing 2D and 3D games and applications that support several operating systems. We developed a game for MS Windows. The main language we use was C#, though we also utilized JavaScript and Boo for simple scripts. Also, we utilized the DirectX library, where the main shader language is Cg (C for Graphics) developed by NVidia.

The input data is not only the users' actions but the current condition of the game world, as the game is a sequence of conditions, where each iteration defines the following one. The artificial intelligence that controls the game characters, random events, and the game mechanics mathematical tool influence the game as well.

The game objects (including the characters, items, etc.) are samples of classes that define their behavior. The game actions (effects, scenes, etc.) are defined by scripts. The game process is defined by the combined action of managers where each controls a certain part of the gameplay:

- GameManager – controls the game cycle and serves as a linker for the elements of game architecture;
- InterfaceManager – controls the user interface, including the graphical interface and the input equipment;
- PlayerManager – controls the main character's behavior and condition (main character here is the one controlled by the player);
- UnitManager – controls the units;
- SceneManager – controls the game levels.

All of the managers are implemented based on the Singleton pattern. They are universal for the whole game, and each exists in a single copy. The managers are called by type. The main game objects base on the Finite State Machine pattern, which allows for easily controlling the game object and controlling its behavior.

The computer game is a complicated system build of separate subsystems integrated into a program architecture. Our game application has the following subsystems: for finding a way for a character; for user graphic interface; for objects interaction and an additional control subsystem.

We implemented the application in several stages and each stage has its tasks (table 1). In addition to Unity, we also utilized the Source Engine. Due to the utilities stated in table 1, we created an application for OS Windows and Android, and also a WebGL library for running in browsers.

2.3 Aspects of Technical Implementation

Creating the classrooms' 3D models was the most complicated part of the development that is why further we describe some implementation details.

To create the classrooms' 3D models, we leveraged separate models of special photos made in advance. Then we utilized Agisoft PhotoScan, which provides for the photogrammetry function (Anuar, 2006). Due to some technology constraints at the moment, building a fully-featured rooms model was a complicated task. Every gleam, as well as translucent materials, causes significant miscalculations. That can be fixed with a flattening spray, though that won't work for rooms, and that costs a penny. Thus, we utilized photogrammetry technology to get objects of correct shapes and sizes (figure 1). Also, we modeled the objects' textures, those we edited via Adobe Photoshop and attached to the models. Using Agisoft PhotoScan we created the model of a classroom and a model of a computer architecture showcase.

Figure 1 demonstrates the 3D-modeled output level of the department rooms. The room modeling was done by brushing geometry, as thus no additional physical attachment model is required.

Figure 2 demonstrates a part of the level, one of the departments' classrooms. Most of the detailed parts were converted into special mdl format for models to allow for optimizing objects in a scene.

The detailed objects in figure 3 were converted into mdl via the proper plugin. After that, we could utilize the graphics power with the model reduction in distance technology – LOD.

When the scene is settled, we can import it into 3DS Max utilizing the WallWorm plugin (figure 4).

3DS Max allows for exporting the scene in FBX format compatible with the Unity engine. In addition to the model itself, it stores data about lightning, materials, and structures.

To make sure that the scene was imported correctly we utilized the projection reflection modes. In figure 5 we can see that the grid is in its normal state.

Unity does not automatically create objects' physical models as it does not allow for brushing geometry. We have to optimize the model in the Unity scene and add a physical model of a connection mesh collider or box collider. The WebGL technology allows for running the project in the Internet browser. This technology is yet imperfect, however, if we optimize the scene it will work well. The mobile systems require the controls to let the user run the game, for the mobile devices do not have keyboards and a mouse pointing device.

Figure 6 demonstrates the controlling elements, the motion controls on the left, and the sight controls on the right.

The home screen interface is a menu that includes options "New game", "Load a game", "Settings", "Exit". After the user loads the game the menu extends with more options. The players can move with the mouse and the keyboard, or via sensor controls. The controls can be set in Settings, in the Keyboard tab. The graphical interface is an upper layer of the graphical system that allows for creating realistic 3D scenes on that basis. These scenes can have their scenario that may be changeable depending on the users' actions.

The game's current version has a static background, though it can dynamically change to another background after each time the player reloads the game. Also, the vital part of the application development process was the scenario creation and quest development.

The scenario development: the game challenges utilize various objects, such as *scripted_sequence* that allows the characters for moving and performing the required actions; *logic_relay* that is used to create the series of events started with some item when it's necessary; *point_template* – a container for storing task objects; *ambient_generic* – used to play audio; *logic_compare* – compares the numbers to decide on what to do next; *info_node* – creates the navigation grid nodes for the non-game characters (the way searching system utilizes the key *info_node* elements), etc. We implemented these elements based on the Finite State Machine pattern, which allows for controlling the game object condition and its behavior. For the quest development there are several algorithms to utilize, though since the game model is 3D, we implemented the way search via the navigation grids algorithm.

The Navmesh or Node Graph navigation grid is an abstract data structure that is usually utilized by AI

Table 1: Tasks and tools for implementation.

Tasks	Tools
Creating 3D models of rooms	Source Engine, Agisoft PhotoScan Pro, GUI StudioMDL
Editing objects	Hammer World Editor, MilkShape 3DL
Creating the objects' textures	Adobe Photoshop, VTF Edit
Creating levels and lightning for some items	Hammer World Editor
Scenes editing, processing, and exporting to the format	3D Studio MAX, plugin Wall Worm
Scenes optimization Adding the physical model of connection Creating game objects and events Developing the game manager, interface manager, player, units, and levels Scripts writing	Unity

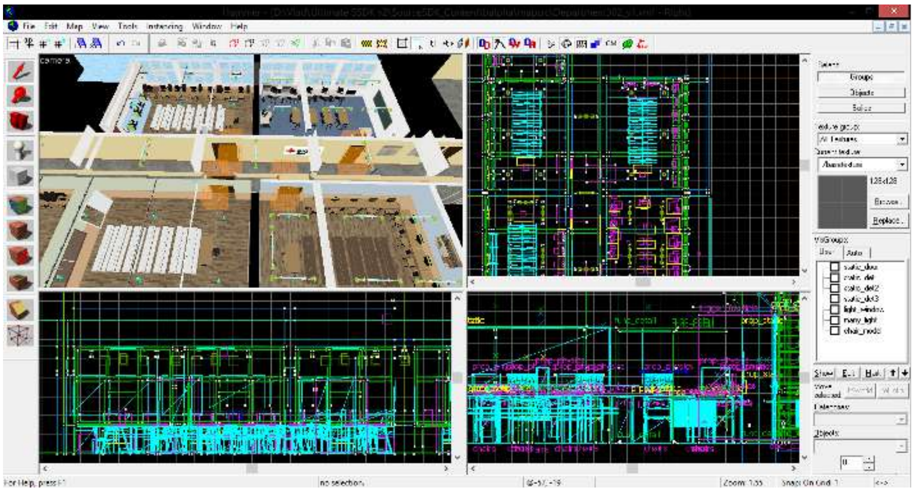

Figure 1: Hammer Editor with a model of department rooms.

applications, to allow the movement agents through big and geometrically complicated 3D objects. AI considers objects that are not static to be a dynamic hindrance. This is another advantage of utilizing our approach to solve the challenge of searching the right way. The agents that can approach the navigation grid do not count these hindrances when building their track. Thus, the navigation grids method allows us to shorten expenses on calculations and makes finding the agents that encounter dynamic hindrances less pricey. The navigation grids are usually implemented as graphs, so we can utilize them for several algorithms defined for those structures. Figure 7 demonstrates the navigation grid utilized to calculate the way for non-game characters.

2.4 Application Scenario

The 3D quest "Passcode" can be downloaded via the following link: https://afly.co/xxn2. To start the quest, the user selects the language, as the game contains tips and subtitles, adjusts the keyboard settings, and on-demand can go to help for instructions in the corresponding menu section. The article (Prokhorov et al., 2020) provides for a simplified game description used for the pilot mode. We updated the game and added more advanced features in the latest release. Thus, further in this paper, we explain the game scenario and provide a detailed description of all functional elements implementation.

The quest contained different challenges to evaluate different groups of digital competencies according to the Digital Competence Framework for Citizens DigComp 2.1, that is information and data literacy, communication and collaboration, digital content creation, safety, problem-solving (Carretero et al., 2017).

The tasks had different constructs and were not limited to linear tests. This allowed us to assess the various cognitive and metacognitive skills of students who participated in the game.

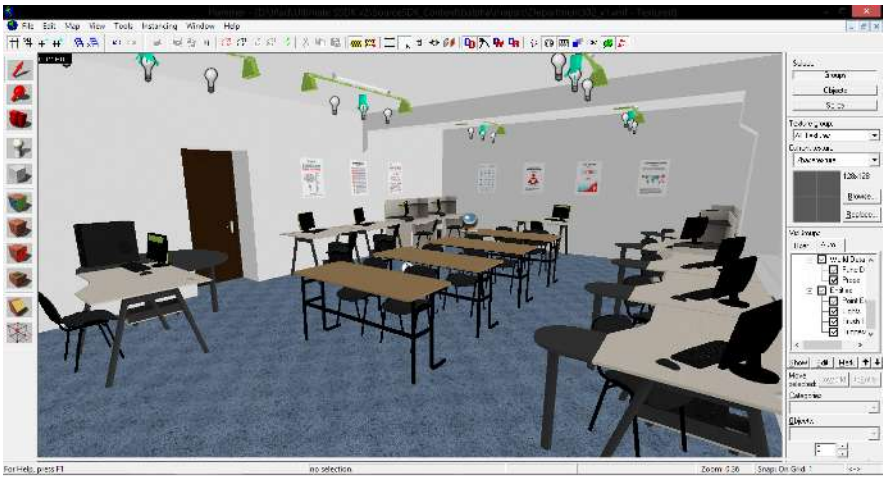

Figure 2: Hammer Editor with a model of department rooms.

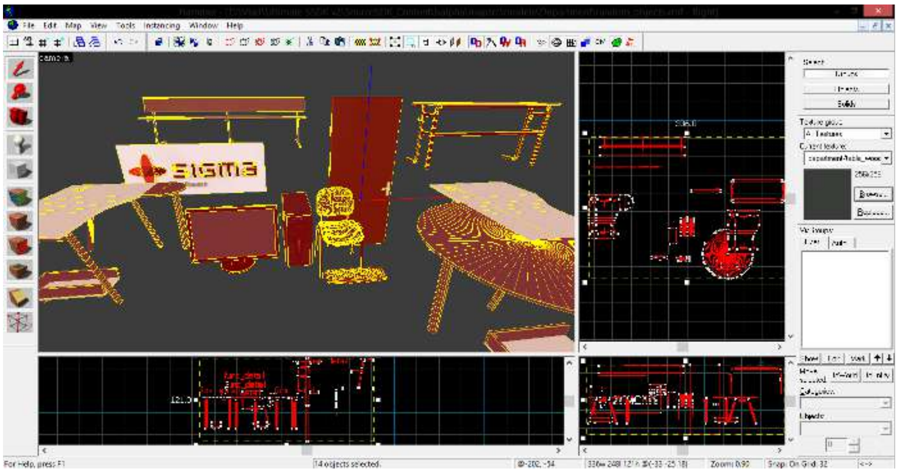

Figure 3: Hammer Editor with a model of department rooms.

Though, to determine the total score we leveraged the approach typical for the majority of computer grading systems: each task has a time limit, and while assessing the performance we consider both the scores and the time spent on the task.

The task constructs in these cases are complex, though due to multi-platform Unity tooling and optimal subsystems interaction, we implemented the complicated game elements and complex evaluation system.

We should note that the game has two modes – the learning mode and the assessing mode. The training mode provides users with a set of prompts and hints and the function that allows for interrupting or canceling the task at any minute. The player can cancel the task with the appropriate button. Also, during the game, the player can see the information on the statuses of completed tasks. Until all tasks are completed, the user will be suggested a new task each time he completes or interrupts the selected task. New tasks will appear until the user completes them all and after that game is considered to be over.

The evaluation mode provides for the limited time on each task, and once the time is over the task is interrupted. In this case, the users' scores are based on their performance. If the task was completed to the fullest extent, the user gets the maximum number of points. If the task was completed partially, the user can score half, quarters, or three-quarters of the points. The evaluation mode doesn't have any prompts that help to complete the tasks, only the prompts that navigate the user through the game. The user is free to choose the order to do tasks, and they also can get back to the postponed tasks unless the time for those tasks has not expired yet.

The game has the following scenario: everything starts when the player appears info_player_start; throughout the parent parameter, the

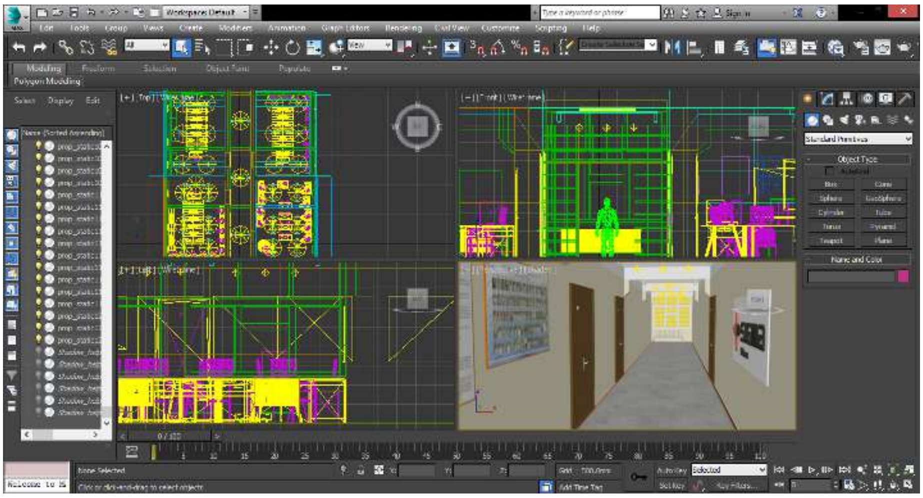

Figure 4: Hammer Editor with a model of department rooms.

Figure 5: Hammer Editor with a model of department rooms.

Figure 6: Hammer Editor with a model of department rooms.

env_entity_maker (cam_i_playersstart_maker) is attached. The env_entity_maker (cam_i_playersstart_maker) includes the point_template (cam_inmenu_point_template) container with the point_viewcontrol

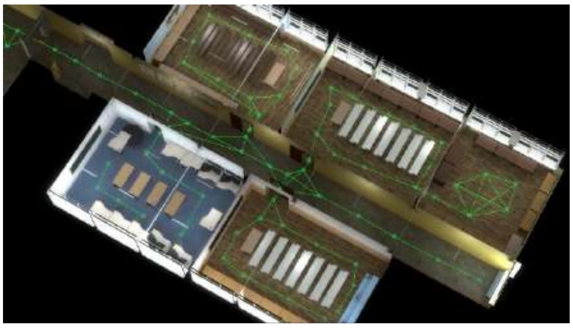

Figure 7: Hammer Editor with a model of department rooms.

(cam_menuv1_point_viewcontrol) camera, the func_brush (cam_menuv1_fadebr) that overshadows the menu background and the info_target (player_old).env_fade that transitions the screen from black to normal.

After the player appears, the rigger_teleport (player_start_trigger_teleport) moves him to info_teleport_destination (playerspawn_depstart) – the end of the corridor in the department that has certain coordinates.

The player receives a number of messages env_message: (Department_WelkomeKhaiDepartment), (Department_TasksButtons), (Department_tasksstart_compl) and (Department_interrupt_ task). After 6.5 seconds, logic_auto activates trigger_teleport (teleport_to_buttons) and moves the player to info_target (tele_player_buttons) – the task menu. Before the player can select a task in the menu, env_entity_maker (cam_i_playersstart_maker) leaves the container point_template (cam_inmenu_point_template) in the previous location of the player.

The task menu consists of five func_button (Button_activate _quest_1-5), script_intro (effect_in _menu) shows the camera effect in the menu. Each button activates its corresponding task script. Any of these buttons refer to logic_relay (buttons_common_relay) when activating the task that disables the menu effect, extra sounds, and messages.

We should note that the game is intended for Ukrainian students and supports only Ukrainian and Russian localizations.

Once the task is selected, trigger_teleport moves the player to their previous location info_target (player_old) so that a player can start a new mission.

The entity responsible for the task completion sends a request to the corresponding env_texturetoggle (Texture_Button_activate_quest_1-5), which changes the buttons' state to "completed".

The math_counter (Math_Completed_procent) counts the number of completed tasks, and logic_compare (Compare_Completed_pr1-5) compares and shows the player their performance in percentage via env_message (Completed_pr1-5). Once the player completes the task, they should select the next task from the proposed.

For instance, estimating the level of competence working with data, the users have to answer multiple-choice questions that cover the information competency (Item 1). These tests can have from two to four questions depending on the test. When the user selects an answer, it is supplied with a corresponding comment and highlighted red (for incorrect answers) or green (for correct answers). For both cases, the user receives a text message with the correct answer. After the user completed test questions, the program counts correct and incorrect answers and displays the results in a message, and voices it over. Figure 8 demonstrates an example of a closed test question, where the user has to choose the correct answer by tapping the number of the computer monitor in the virtual classroom.

The task has the following implementation. In the beginning, the player sees the message env_message (Department_Quest_1_502_goto504) that tells the player an audience to go. Once the user is in the right audience, trigger_multiple (Department_Quest_1_504_as1_triggershowMSG) activates the task.

The player sees the message env_message (Department_Quest_1_502) on the screen, then several buttons appear: func_button (button_que1_1-4), logic_case (quest1_logic_case) and the user should randomly select the first question. For each question, QUE1_1-16_relay utilizes math_counter (quest1_math_voice_number) that announces the question's number, ana func_
brush (QU1_monitor_image *) displays the picture on the in-game monitor.

To estimate the users' competence in problem-solving and communication, we developed the "Find the academic record book" challenge (Item 2) (figure 9). The scenario supposes the user to communicate with the Student character, ask her questions on the educational process and decide where to go to find the academic record book. To provide for an additional challenge, this item randomly appears in one of the departments.

When the user finds the object, he receives a message about discovery and he can go find the academic record book. After he gets the academic record book in his hands, he leaves the department and the challenge is over. The game counts the number of steps the user made to complete the task.

When the user finds the object, he receives a message about discovery and he can go find the Student. After he gets the academic record book in his hands, he leaves the department and the challenge is over. The game counts the number of steps the user made to complete the task.

To accomplish this task, we utilized: info_node, scripted_sequence, npc_template_maker, npc_natasha, env_message, logic_relay, logic_choreographed_scene, filter_activator_name, trigger_multiple, logic_case_ trigger_teleport, fun_tempergetge, info_thanplate.

Let's consider these entities closer. info_node is a node intended for creating a navigation network, required to move non-game characters in three-dimensional space. Each info_node has an ID. For a particular task, such a character is npc_natasha a student who uses the network to move around the level. The more info_node will be used on the level, the bet-

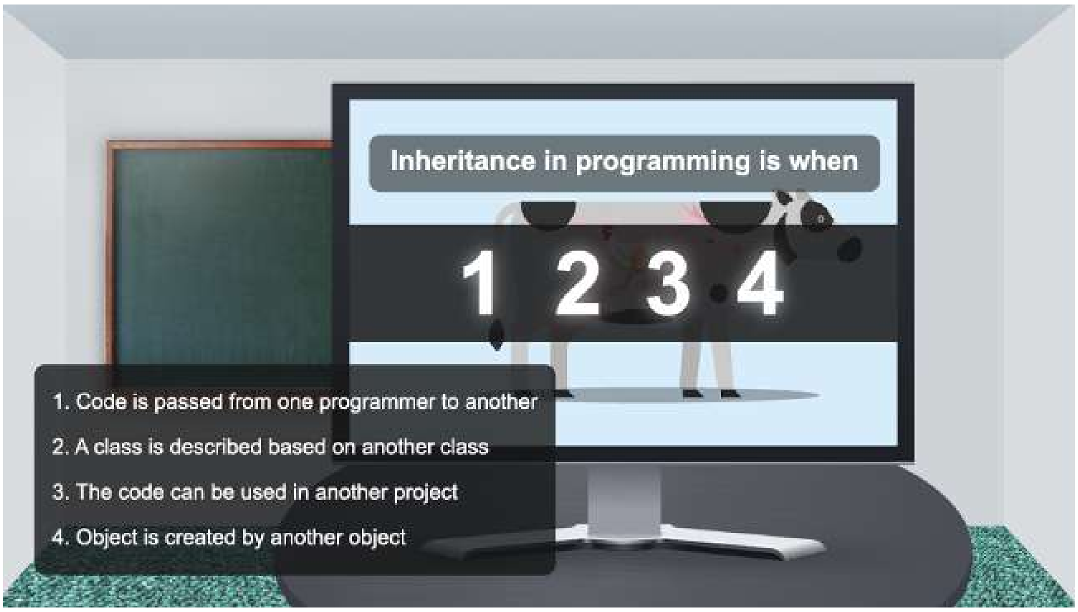

Figure 8: An example of the question from the 3D quest game.

Figure 9: An example of the question from the 3D quest game.

ter the navigation network will be. Though the aim is to build a correct and efficient network, that means that the nodes should be used even for the narrow doorways to connect different rooms in a network. Otherwise, the non-game characters won't be able to walk through the doors because they cannot get from one isolated network to another. Besides, the non-game characters will always choose the shortest way through the network from point A to point B. In case if the character encounters two roads of identical length the character will choose the road with a smaller ID number. The npc_natasha entity uses other entities intended to implement various actions. The npc_natasha entity is a source for cloning. This is a non-game character that is a female 3D model, which implements basic AI functionality. To move around the level this character utilizes the script files with scripts and the navigation network.

Other entities and their purpose are listed in table 2.

The "Clean the classroom" challenge (figure 10) aims to evaluate the user's ability to solve technical problems, follow the rules of safety, and treat the technical equipment and computers (Item 3). The user has to place computers, screens, mouses, and keyboards around the classroom in the right places. The game counts the number of steps the user made to complete the task.

In another classroom, the user has to set up a computer out of suggested elements (the computer cabinet, processing unit, mother card, power source, cooler, graphics adapter, RAM, etc.). This challenge counts the order; thus, the user can't place the cooler before settling the processing unit into the mother card. After the computer was set up, the user is told the number of a room where to take the computer. The task is considered to be complete when the user takes the computer to the given classroom.

Table 2: The entities used for the 3D game scenario implementation.

Entities	**Purpose of use**
scripted_sequence	required for programming the script scenes with non-game characters. Allows for the characters moving to specified locations, playing animations, and playing sound files.
npc_template_maker	a container for creating a non-game character at the selected moment, for example, if the player wants to repeat a task.
env_message	displays the message at the player's screen. The messages are stored in a text document and can be edited.
logic_relay	triggers the selected chain of actions of the scene level. Can be performed either once or several times.
logic_choreographed_scene	stores a link to a scene file via Face Poser. Scenes contain the advanced combination of character animations, facial animation, and their speech. One scene allows for managing several characters simultaneously.
filter_activator_name	serves for filtering the entities by name. Required in places of various objects interaction. For example, according to the task, the player cannot give the student a chair instead of the record book. In this case, we filter the record book by name using this entity.
trigger_multiple	is a three-dimensional, geometrically constructed trigger at the level, activated when physically encounters the activator. Any entity can be an activator.
logic_case	the trigger required to activate the random chain of events. Utilized for the test tasks.
info_target	a target or a point. The point can locate at any coordinates within the scene. info_target is utilized by other entities as a target or location.
trigger_teleport	it is a trigger for moving entities to a specific point specified in it. The point is defined in the entity info_target.
point_template	an entity that serves to create and clone other entities on call. Mostly used when a player wants to replay a task.
func_physbox	is a three-dimensional entity of the convex shape that behaves like a physical object. For example, the test book in the task.
prop_dynamic_override	an entity that serves to create a dynamic model bypassing the constraint criteria (dynamic/static). This entity can play animations.
ambient_generic	stores the links to the audio files. The entity is used for all tasks, allowing for looping the sounds.
func_door_rotating	serves to create doors that can be opened by the player.
prop_door_rotating	serves to create doors that can be opened by non-game characters. The non-game characters can open these doors if they are closed or block the way.
func_button	the trigger button that a user can press to initiate a certain sequence of actions. Used in-game to select tasks, and for the tests and puzzles that allow for interrupting the task.

For the task we use the following entities: info_target, prop_dynamic_override, prop_physics, trigger_teleport, func_brush, math_counter, filter_activator_name, func_button, ambient_generic, env_message (table 2).

Also, we used the entity math_counter to perform such arithmetic operations as addition, subtraction, multiplication, and division. This entity is applied for counting the player's score or the number of tests.

The next task is to "Assemble the computer" (Item 4). The player is asked to assemble a system unit from various components (figure 11). The player has the following items: the case, processor, motherboard, power supply, cooler, video card, RAM, hard drive, and side cover. For this task matters the order of actions, for example, you cannot install a cooler until the processor is installed on the motherboard.

Due to the technical aspects, the components must be installed only inside the system unit, but not outside it. That means the user cannot install the processor in the motherboard outside the system unit. Once the system unit is complete, the user is told which audience to take the computer. After the player brings the computer to the right place, the task will be com-

Figure 10: The user got the task to settle the classroom and completed it.

Figure 11: The player received and completed the task to assemble the computer.

pleted.

This task consists of the func_detail, point_message, env_message, filter_activator_name, func_button, ambient_generic, env_projectedtexture, trigger_teleport, info_target, logic_relay, func_brush, func_physbox, point_ountericplate (table 2) entities. The additional entities for this task were:

- func_detail – three-dimensional convex-shaped entity used to create walls and structures, has no name and should not be taken into account when creating level scene optimization;
- point_message entity that displays text prompts located in three-dimensional space. Used to suggest component names in a task where the player has to assemble a system unit;
- env_projectedtexture entity used to create a dynamic light source with a shadow. Located in places where it is required to highlight some stage areas for better convenience. Highlights the areas in tasks with assembling the computer block and puzzle games.

To evaluate the users' abilities for self-education and career guidance (Item 5), the user has to put together the "IT specialist jigsaw puzzle". The task is to group 30 suggested elements according to 10 given IT-related occupations: Mobile Developer Android, Mobile developer iOS, Frontend developer, Backend developer, Project manager, Java developer, .NET developer, UX/UI designer, QA tester, Database developer. The number of pieces for each occupation varies from 3 to 6, similar pieces can belong to different occupations. The order in this challenge doesn't matter, and the number of attempts is not limited. The assessing mode has a time limit. The pieces that do not match automatically drops away, denoting the mistake. The challenge is complete after all the pieces are together (figure 12).

During the challenge, the user can get tip messages by clicking the occupation name, and it shows up for 10 seconds. The tips number is limited, and the game counts how many of that user took.

The task with puzzles includes the following entities env_message, filter_activator_name, func_button, ambient_generic, env_projectedtexture, trigger_teleport, info_target, logic_relay, func_brush, func_physbox, point_template, game_textter, englec.

All entities were previously considered for other tasks (table 2), the additional entity here is phys_keep_upright, used to hold physical objects in a defined position, allowing for setting the angle. The entity serves to keep puzzles in a certain position.

The tasks are meant not only to evaluate the users' digital competence but also to learn about the faculty life and educational system as the game models reflect real objects.

Figure 12: The user processing the jigsaw puzzle task.

At the moment, the quest has 5 challenges, though we have an opportunity to make changes to the tasks pull. To succeed, the user has to complete all of the challenges, yet the order can be random. To choose the challenge the user just picks one by clicking on it, and the voice behind the scene explains the message and the point for him to go. As the user reaches the right classroom the voice behind the scene provides detailed instructions for the challenge. When already moving, the quit option becomes available for the user. To disrupt the challenge the user should press the corresponding button in the classroom or use a keyboard shortcut.

Completing each task is always written, its color changes from red to green. During the process, the user sees the score of the challenges he completed. There are certain evaluation criteria, though every task is scored 4 points. The maximum score is 20 points. Depending on the complexity the tasks value differently. The system defines the applicants who scored less than 10 points to have a low level of digital competence, from 10 to 15 points – the middle level, and those who scored above 15 – to have a high level of digital competence. Also, each challenge has no time limits, yet the quest time was limited. Thus, we could evaluate the users' ability to plan their time and decide on the order and timing for the challenges they take.

3 THE EXPERIMENT RESULTS

To evaluate the quest efficiency we held an experiment at the IT championship for the applicants at the computer science and information technologies department in the National Aerospace University "Kharkiv Aviation Institute", which results are demonstrated in the article (Prokhorov et al., 2020). This paper compares the results of students who passed the quest on a computer and in real life. The analysis proved that the difference in results of two groups of students who participated in the IT championship is not significant, and confirms the results of the previous research (Özalp-Yaman and Çağıltay, 2010; Ita et al., 2014). However, the teenagers were mostly attracted to the 3D game.

In 2020 the championship occurred in the University for the fourth time, and the applicants were suggested the 3D game challenge. Due to the pandemic, all students participated in the championship online, while we calculated their scores and defined the winners (https://www.youtube.com/watch?v=3HRz2GoudeA).

In general, we registered 180 students from 35 schools, though only 116 students participated in the game and completed all tasks.

There were 84 boys that equaled 72% and 32 girls that equaled 28% of participants. To process the overall applicants' results we applied statistical analysis from the R packages (Kabacoff, 2021; Field et al., 2012). We calculated the average for girls and boys. Figure 13 provides for the distribution of the scores. Boys demonstrated better results (average score equal 10.7) than girls (average score equal 9.8), but the difference isn't statistically significant (the Students' criteria equals 1.18 at p=0.23).

To verify that the tasks are valid and applicable to access the applicants' skills in the field of computer science we carried out the psychometric analysis. We defined the task complexity score that demonstrates

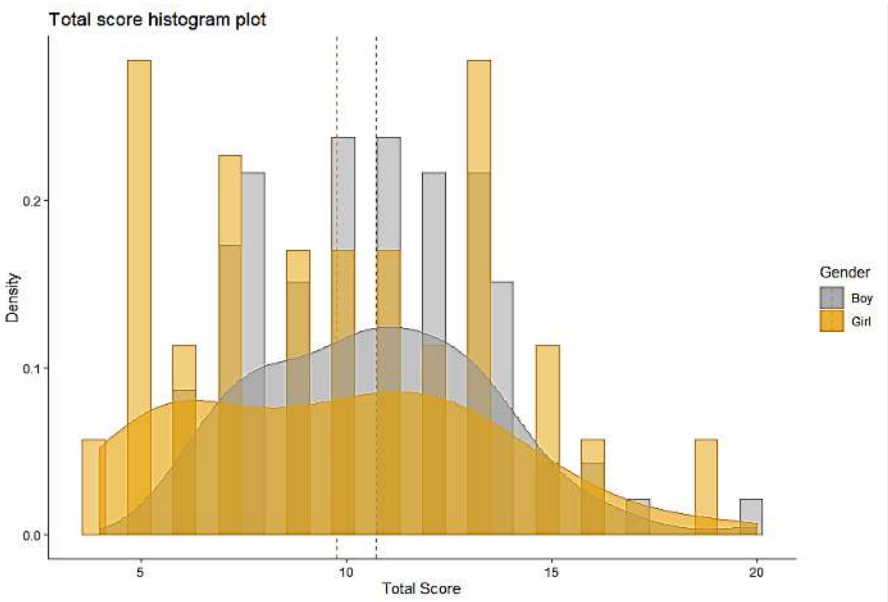

Figure 13: Scores distribution on the 3D game results.

the participants' performance on certain tasks and the coefficient of correlation of tasks to the total score, that characterizes the consistency of test tasks. The obtained results are in table 3.

The results prove that items 1 and 5, those suggested to answer the questions related to the IT industry and to assemble a puzzle were the most complicated in the 3D game (47% and 46% of students accordingly got the maximum scores). This proves that we should carefully approach creating the tests, considering the target audience's cognitive skills and the test intended use.

Items 2-4 appeared to be easier for the students (63%, 52%, and 52% of students accordingly got the maximum scores) since they didn't aim to assess the knowledge but to assess the ability to navigate through the game and concentrate. Thus, in accomplishing these items, students had to demonstrate metacognitive skills.

Though, considering the correlation of scores for these items to the general score, the fiesta item correlates the most (the correlation coefficient equals 0.6). That means that the students who answered IT-related questions better showed overall higher results. The general difficulty on all test tasks is 0.2, that is the middle level of difficulty. The results confirmed that the tasks are reliable and adequate for determining the level of digital competencies precisely for future applicants of the IT departments.

The analysis concluded that the format of test tasks allows not only to determine the level of participants' competencies but also to define the skills that should be developed. The tests in the format of a game that automatically collects data allow for defining the digital competencies profile for each participant. This profile can be analyzed and compared to a sample "desired" profile to decide on career guidance and training strategy. The profile analysis allows defining the competencies that do not require development, the competencies that require development, and the missing competencies. To provide for an integrated assessment of the participants' competencies, we used the weighting and ranking method. As a result, we received a clear picture of the skills that the participant has already obtained and the skills that should be developed so that a participant could enter the IT-related department and successfully study there.

However, the middle level of the participants' digital competence didn't decrease their interest in our evaluation approach. This fact is important not only for the future IT specialists but also for the departments' occupational guidance process. The students mostly coped with the tasks and provided positive feedback on participating in the game.

4 CONCLUSION

Out of the aim of this research and the particular tasks we faced developing a 3D quest game, as well as the results of assessing the application efficiency in career guidance we came up with the following conclusions.

The game application development technology we

Table 3: Statistics of items.

	Item 1	Item 2	Item 3	Item 4	Item 5	Total
Difficulty	0.47	0.63	0.52	0.51	0.46	0.52
Correlation	0.60	0.59	0.51	0.51	0.43	

suggest can be utilized by 3D models and game developers, in particular for training future IT specialists.

We utilized various technologies to implement the application idea. Leveraging Unity 3D and Source Engine as the main engines allowed for creating a 3D model of a game and its main objects. We edited objects via Hammer Editor and created a realistic department's classroom model with the Agisoft PhotoScan Pro tool and photogrammetry. Searching the right way was implemented via navigation grids, which allow through the geometrically complicated 3D objects.

The game scenario provides for a virtual tour around a department of the 3D university. As far as the game replicates the real-life objects, applicants can see the department's equipment and classrooms.

During the quest development, we considered the requirements to the participants' characteristics, game environment, and utilizing various types of tests with hints and voicing over, that contributed to the accurate evaluation and increasing the students' motivation to acquire the IT-related profession, in particular building the models and researching.

The quest includes several different challenges meant to evaluate the applicants' digital competence connected to the DigComp 2.1 framework components such as information and data literacy, communication and collaboration, digital content creation, safety, problem-solving. The tasks also allow for understanding the applicants' ability to work efficiently and to use computers in real life.

The experiment results prove the 3D quest to be effective. According to the results of the 3D quest, applicants demonstrated an average level of digital competence with a certain item test difficulty at 0.5. This indicates that applicants made a conscious choice of the faculty and they are ready for further study. Our psychometric analysis confirmed the reliability and consistency of the test tasks we developed.

The applicants estimated a 3D quest, as more up-to-date and attractive engagement. Also, they claimed this up-to-date approach would influence their choice of a university. The general results of the test tasks outlined the areas for enhancement and showed what digital competencies the students yet have to obtain.

Thus, our 3D quest application can grow the audience for career guidance activities and improve the public image of the university. Besides, applicants can use this 3D quest to decide on their future occupation.

In addition to campaigning and career guidance, this application can help to teach and test students. To do this, several psychometric indicators of 3D quest tasks were analyzed to allow further improvement for the items' quality.

The prospective research aims become pending due to switching to digital learning. These aims are to create a convenient and effective environment for digital learning using VR and AR technologies, to utilize the application for evaluating the digital competence of the future IT specialists, and adjusting the educational plan for the university's first-year students.

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360° Photographic Panoramas as an Effective Multifunctional Aid for Teaching Technology Subjects

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Abstract: Rapid development of modern machinery and its increasing complexity make high demands to the quality of training of its users. Among the variety of kinds, the important one is vehicles, both civil and military. In the teaching of associated subjects, there is an accepted hierarchy of teaching aids that includes common visual aids (posters, videos, scale models etc.) on the first stage, followed by simulators ranging in complexity, and finishing at real vehicles. It allows achieving some balance between cost and efficiency of training by partial replacement of more expensive and elaborated aids with the less expensive ones. However, the analysis of teaching experience in the Institute reveals that this balance is still suboptimal: the quality and abundance of common aids may be increased, and the simulators may be used more effective. This fact raises the problem of extending the range and quality of available teaching aids for vehicle-related subjects, which is the aim of the work. Benefiting from the modern information and visualization technologies, we present a collection of new teaching aids, which are based on 360° (spherical, 3D) photographic panoramas joined with H5P interactive content framework or virtual reality devices. The nature of the aids, their potential applications, limitations and benefits in comparison to the common aids are discussed, and the practical recommendations about creating and implementing the aids are given. The proposed aids are shown to be cost-effective and proven to increase efficiency of training, according to the results of a teaching experiment. For the implementation, a tight collaboration between the Institute and an IT company was established. The authors conclude that the proposed aids may significantly improve the cost-efficiency balance of teaching technology subjects.

1 INTRODUCTION

Technology plays a vital role in modern world. At present, most occupations and activities imply utilization of some devices and equipment. Among the variety of classes, an important representative is vehicles. A wide assortment is designed and extensively used in civil (transport, building, service etc.), military, and paramilitary (emergency, police) fields. The following features are typical for modern vehicles and their exploitation process:

- increasing complexity of the chassis itself and the installed equipment;
- fast development, resulting in frequent appearance of upgraded and novel models;
- often, hard use conditions (especially for military and paramilitary vehicles);
- high costs of repairing and replacement of broken samples.

Consequently, extensive knowledge about the proper exploitation of the vehicle and related skills must be delivered to trainees during education in order for them to become qualified users.

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2 RELATED WORK

In the teaching of vehicle-related subjects, there is an established and accepted hierarchy of teaching methods and corresponding aids (Course, 2019). It is summarized in table 1.

Table 1: The accepted hierarchy of teaching aids in teaching vehicle-related subjects.

Stage	Teaching aids	Goals
1	Common visual aids (posters, animations, videos, scale models etc.)	Provide the knowledge about the constitution, functioning, appearance, and exploitation of the vehicle. No skill developing is assumed.
2	Simulators	The purpose is two-fold. Firstly, providing information about appearance and exploitation of the vehicle. Secondly, a more or less wide range of skills may be trained, depending on the class of simulator.
3	Real vehicles	Providing real-world driving experience and developing exploitation skills.

An extensive literature, both pedagogical and technical, is available about the problems of design and use of simulators (Rusilo, 2010; Rudkovs'kyy, 2013; Prihodko, 2009; Vakaliuk et al., 2020). The transition from the first-stage aids to the last-stage ones is characterized by two trends. On one hand, the trainee's experience becomes more relevant to the real-world use experience. On the other hand, expenditure for material resources and time per one trainee increases, as well. The reasons are manifold:

- a vehicle and, to a lesser extent, a simulator are expensive to obtain and maintain;
- exploiting vehicles is resource-expensive;
- each vehicle or simulator is able to accommodate a single trainee only and, thus, have very low throughput: each trainee has to enter and leave it one by one.

The above hierarchy is aimed to balance the quality and cost of training, which is to provide the best training for a given budget, by partial replacement of more expensive aids with the less expensive ones. The stated aim is actually achieved.

3 STATEMENT OF PROBLEMS

Nevertheless, the analysis of teaching experience collected in the Institute reveals that the reached balance is still suboptimal.

The first identified deficiency is the extensive use of simulators just as advanced visual aids, when they act simply as 1:1 scale models. Their purpose here is just familiarizing the trainees, who are already taught with textbooks, posters, videos, with the actual appearance of the vehicle cabin (location of controls, indicators, handles etc.). "Familiarizing" here means establishing the connection between the remembered flat two-dimensional pictures of the cabin with its actual spatial three-dimensional appearance and working out the head, arms, hands movements needed to activate the learned controls. This fact leads to the next problems:

- Trainees are able to occupy the simulator one by one only, extending the duration of the class (i.e. the throughput is very low).
- The time available for using the simulator at its full capacity for developing skills by other trainees is, thus, reduced.
- In education establishments, which do not possess a simulator, the trainees are unable to receive this kind of training.

Let us consider a simple example. In a group of 15 trainees and one teacher during a 75 minutes class each person will receive just 5 minutes of experiencing the simulator in the best case (i.e. no preliminary instruction is needed, entering and leaving the cabin occur rapidly etc.). Importantly, the teacher is focused on the single trainee sitting in the cabin and, thus, cannot perform teaching with the rest of the group. Simultaneous utilization of 3–4 simulators may improve the situation but requires corresponding expenses. The reason of such unpractical use of simulators is the absence of other teaching aids, which can be employed instead. In other words, there is a pronounced gap between the first and second hierarchy positions, which is forcedly filled by simulators. It is illustrated in figure 1 where the particular sensational features provided by the discussed teaching aids are shown (Barkatov et al., 2020).

In the described situation only the two basic sensational features of simulators are used out of four that is evidently suboptimal.

The second identified deficiency is while the basic teaching aids (posters and videos) are generally available at present, their abundance is still limited, and technical level often does not meet the standards of

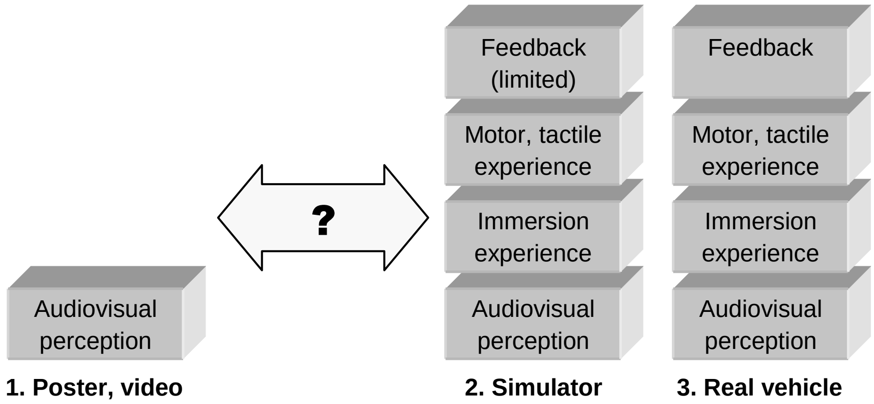

Figure 1: Sensational features provided by the teaching aids in the accepted hierarchy. The complexity and cost of implementation increase top to bottom and left to right. The question mark represents the gap.

modern technology. Videos and animations are valuable means for teaching technical disciplines, which study the structure and functioning of mechanisms and systems. If the former is relatively easy to learn by means of static posters, drawings, diagrams, the latter implies understanding some processes occurring in time and, thus, demands animated visualizations for effective learning. The same is true for studying exploitation of devices, including vehicles, where the object to learn is the procedure (sequence of actions) that must be performed by operator (trainee) to get some result. Importantly, the role of such aids strongly increases in conditions of distance learning when the access of trainees to simulators may be limited. Therefore, the problem of improving their quality and abundance deserved thorough attention.

To create a teaching video about vehicle one needs corresponding visual content, which at present is obtained in either of two ways:

1. Manual drawing a flat or three-dimensional (3D) model of the vehicle from scratch using specialized graphics or engineering software (3D Studio MAX, SolidWorks, AutoCAD etc.), with further animating it.
2. Recording the video of performing operations on a real vehicle using camera.

Unfortunately, both ways are associated with significant difficulties, which limit their application in practice:

- The first way is very labor-intensive. It requires having highly detailed information about the vehicle (dimensions and appearance of its elements). Further, the model prepared in such a way looks noticeably idealized compared with the appearance of the real vehicle. Also, rather high skills are required for creation.
- For the second way, video recording in confined premises like vehicle cabins is difficult and requires appropriate skills and equipment. Moreover, the collected video material cannot be reused: each sequence of operations in vehicle must be recorded individually. In total these factors make the process time-consuming and labor-intensive, too.

Summarizing, the available range of teaching aids is markedly incomplete, and their creation (posters, videos) or use (simulators) is connected with severe difficulties. This reduces the quality of teaching vehicle-related subjects. The goal of our work is to introduce new teaching aids in order to increase the stated quality.

4 OVERVIEW OF USED TECHNOLOGIES

We propose a collection of teaching aids built around 360° photographic panoramas possibly connected with H5P framework or virtual reality (VR) glasses. In this chapter we shortly summarize these technologies.

360° panorama (also called spherical or 3D panorama) is an image that covers and contains the full horizontal and vertical field of view around a fixed point. It may be either artificial (i.e. drawn manually or computer-generated) or photographic. The photographic ones are created by processing a number of ordinary photographs (each having field of view less than 180°) shot from the same position to all the directions around (Wikipedia, 2020; Grinev, 2019). The principle is shown in figure 2. Specialized software is used for this sake, which generates smooth and continuous transitions between neighboring shots. Unlike ordinary images, 360° panoramas obviously cannot be viewed as a whole without slicing, therefore, when viewed on displays they are scrolled to the position of interest using computer mouse or other input device. If the target comprises of several sections then an individual panorama should be shot and fabricated for each of them. The user has to switch between them at viewing. At present, they are mostly used for advertisement and entertaining purposes, however, some educational use is also made (e.g., panoramas of museum interiors) (Authentic Ukraine, 2020).

Figure 2: The principle of composing a 360° photographic panorama. The camera is located in the center of the field of view. A single photograph shot is shown explicitly, while for the rest only borders are shown.

H5P (acronym of HTML5 Package) is a framework allowing users create and demonstrate multifarious interactive multimedia content, such as quizzes, interactive videos and presentations etc. The framework is designed such that its use is simple and does not demand special training in information technologies. It is based on a set of Web-related technologies, hence, the content can be created and viewed using any modern Web browser without the need of additional software. Further, it is well-integrated with learning management systems providing the opportunity to enrich distance courses by incorporating interactive content (Scherbyna, 2016).

Virtual reality is a system designed to create the effect of the person's presence in some environment, either having a real counterpart or missing it, by specific affecting their sensors (eyes, hears, skin etc.) via special equipment and software. This effect is usually called "immersion" in the literature. The central component of the equipment is a head-mounted display (called VR glasses), which form the person's field of view by displaying the picture that is provided by VR software. The most important feature of the glasses is interactivity: the movements of the person's head are monitored, transferred to the software and processed by it for the sake of updating the image in accordance with the new direction of the head (Singh and Singh, 2017). This turns a passive spectator into an active viewer who is able to look around.

In general, the possibilities of utilizing VR in teaching various subjects have been actively discussed for several decades, and different software and hardware solutions were proposed. Mostly, the fields where practical study involves large hazard or expenses were worked out, for example, medicine (Satava, 1993; Rowe and Cohen, 2002; Gallagher and Cates, 2004), technology and fire safety (Ren et al., 2006; Ooi et al., 2019; Zhao and Lucas, 2015; Sampaio et al., 2010; Wang et al., 2018), driving (Bayarri et al., 1996; Kang et al., 2004). At present, it became an accepted aid, particularly, in medicine and military training (Bhagat et al., 2016; Lele, 2013), while in other fields its usefulness is still discussed. For detailed reviews of the place of VR in education, the reader is referred to subject papers (Wang et al., 2018; Lavrentieva et al., 2020; He et al., 2017; Pantelidis, 2009; Osipova et al., 2019; Kramarenko et al., 2020).

5 PROPOSED SOLUTIONS

Basing on a above stated technologies we propose a collection of teaching aids, which we think fills the identified deficiencies well. It is represented in figure 3. Now we will discuss each aid individually.

5.1 Teaching Video

Yet, firstly we describe the possible application of 360° panoramas for making traditional teaching videos. We argue that they can readily serve as a source of visual content for this sake, hence eliminating several related difficulties (see chapter 3):

- Fabricating a photographic panorama is much less labor-intensive and time-consuming than drawing a high-quality poster or 3D model because it does not involve manual reconstruction of the vehicle appearance from scratch. Instead, making a series of photographs is a routine process, and composing the panorama is almost completely automated by software.
- In contrast to recording videos, less skills and simpler equipment are needed for photography. Further, a panorama contains complete information about appearance of the vehicle or its cabin. Therefore, once manufactured, it can be repeatedly used to make a video on any procedure involving this vehicle.

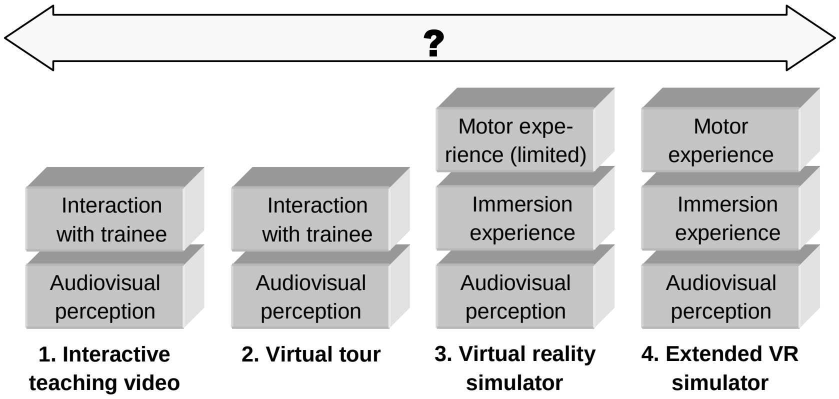

Figure 3: Sensational features provided by the collection of proposed teaching aids, which fill the gap (represented as the question mark).

We propose the following algorithm of making videos basing on 360° panoramas:

- Display the needed panorama on the computer screen.
- Start screen capture together with sound recording from microphone using the corresponding software.
- Consider the first action of the chosen procedure.
- Scroll the panorama to show the view corresponding to the current action.
- Point, which control has to be activated or which indicator should be noticed, by drawing remarks on the screen using corresponding software.
- Voice the performed action and accompanying commentaries.
- Repeat steps 4–6 for the next action until the procedure is finished.
- Stop screen capture.

Among others, we made a teaching video on procedure “Preparation to starting-up and starting-up of the engine” using 360° panorama of BTR-4E shot by us previously. It describes the sequence of 19 actions that trainee in the role of driver has to perform.

5.2 Interactive Video Lesson

As far as 360° panoramas facilitate making traditional teaching videos, they as well assist making the H5P interactive video lessons. The feature of this kind of multimedia content is that it allows incorporating various interactive elements, such as appearing explanations, images, tables, bookmarks, links. During watching H5P interactive video lesson, the user visually and audibly receives information about the procedure they needs to perform. Various test tasks can be added, as well. At a certain point, the video stops playing, and Moodle expects the trainee to perform some action within this video. The playback will continue once the trainee selects the correct action.

The main advantage of this interactive approach is that the trainee takes an active part in the lesson instead of being a passive spectator, which forces them to be more attentive and focused during watching. Importantly, fabrication of such lessons is rather non-complicated and does not require additional software (they are developed in a Web browser). Such videos can be integrated easily into courses created within Moodle learning management system (Polhun et al., 2021).

Based on the previously mentioned panorama-based teaching video (chapter 5.1) we have made an interactive video lesson, which was then integrated into the distance course “Structure and exploitation basics of BTR-4E”. The course is published on the Institute’s Moodle platform (dl.khpi.edu.ua, 2020). The next interactivity was added: algorithm of actions in text format, the values shown by indicators during procedure, labels indicating the location of the main devices and controls of the BTR, control questions the trainee has to answer.

5.3 Virtual Tour

Apart from using just as a source of visual content for making videos, the 360° photographic panoramas themselves are excellent teaching aids that surpass other sorts of multimedia:

- The complete information of the vehicle appearance is structured and collected in a single piece of multimedia that can be explored in a natural way.

- The exact correspondence between the panorama and actual appearance of vehicle elements makes them recognized easily when a trainee enters the real cabin.
- Smooth and continuous exploration of a panorama creates a solid and coherent image of the vehicle interior or exterior in the trainee's mind.

A 360° panorama that can be interactively viewed (scrolled) is called "virtual tour". Optionally virtual tours include some additional content (texts, multimedia) and links to related panoramas (e.g. those of other rooms in an apartment or sections in a vehicle). Displaying and hiding this content and transition between panoramas is done by activating markers, which are placed at chosen points of the panorama.

Demonstration of virtual tours does not require special software and is done in a Web browser. This appears an essential advantage because allows native integration of the panoramas with Web-based learning management systems, such as Moodle. It is done using H5P framework. For Moodle, teacher firstly has to open Content bank and add a content item of type "Virtual Tour (360)", then upload the fabricated panorama there. After this, the described markers for trainee's interaction with the panorama can be placed. The starting position and direction of the view should be set. We recommend firstly load all the panoramas of the vehicle (each its section, maybe its exterior, as well) and then connect them with transitions by means of placing such markers.

We turned the abovementioned 360° panorama of BTR-4E into a virtual tour and integrated it into the distance course (dl.khpi.edu.ua, 2020). Numerous teaching information was added by means of H5P:

- labels of cabin elements and controls to speed up memorization of their location and main purpose;
- schemes to explain the internals of the cabin elements and their connection and interaction with each other;
- video clips to animate the panorama and show the controls and indicators in action;
- control questions to allow teacher check the memorization of material by trainees.

5.4 Virtual Reality Simulator

Despite the rich opportunities provided by software, the full potential of 360° panoramas may be utilized only if they occupy the whole field of view of a trainee instead of being viewed on a distant display. Virtual reality is the technology that makes this possible. It allows imitate the presence in a real premise depicted on the panorama and achieve the effect of "immersion". Hence, it becomes advantageous to employ VR glasses for viewing 360° panoramas. The next benefits can be reached:

- The image of the 360° panorama appears completely surrounding the trainee, convincingly imitating staying inside the premise.
- The panorama becomes interactive, i.e. responding to the look-up movements of the trainee's head.

Also, the trainee becomes able to perform movements of arms and hands in order to imitate using controls seen in the field of view. Although the former are not visible in VR glasses (without involving additional elaborate VR equipment), this is still useful and provides correct (through incomplete) motor experience because the location of controls in the field of view displayed by VR glasses is the same as inside the vehicle cabin. This feature even more distinguishes this teaching aid from common visual aids (posters etc.), which are unable to provide reasonable motor experience.

Summarizing, the combination of a 360° panorama and VR glasses is able to provide visual perception plus both immersion and limited motional experiences. Hence, it is located in between posters and simulators in the diagram (figure 1) filling the gap described in chapter 2.

Yet, there are several difficulties arising during practical use of VR at classes.

Firstly, while the teaching aids stated above do not require special software for use, here, a dedicated software must be developed that receives the data about head rotations from VR glasses and performs scrolling the panorama. We solved this problem by means of a collaboration with IT company (chapter 5.6).

Secondly, the teacher is unable to monitor the actions of the trainee because they is unable to see the image on the VR display. Therefore, in order to allow controlling the trainee's actions, a supplementary display is needed, whose purpose is to demonstrate the image that is displayed by VR glasses at the moment.

The third difficulty is the very limited ability of the trainee wearing VR glasses to answer teacher's questions about the image seen (e.g. "indicate the button named X on the control panel"). It is caused by the fact that by default, the environment is interactive just to some extent: it responds to the rotations of the user's head, but the user is unable to affect it in any other way. To solve this problem, the trainee has to be provided with a separate device called "controller". Its purpose is to receive the user's input and affect the image seen in the VR glasses and, as a result, on the teacher's computer display. For example, the trainee would draw lines and other marks on the displayed panorama, in such a way answering teacher's questions. A simplest controller is computer mouse.

Taking all the above into account, the proposed VR simulator consists of four components, which are depicted in figure 4. It may be implemented using a range of hardware; the authors' choice is stated in chapter 5.6 (Barkatov et al., 2020).

5.5 Extended Virtual Reality Simulator

As it has been mentioned in the previous section, the VR simulator in the present implementation lacks some useful features. Firstly, the trainee does not see their hands, therefore, the arms movements imitating reaching vehicle controls has to be made blindly. Secondly, there is no tactile experience: the movements of hands and fingers imitating activating vehicle controls are made in empty space that does not provide tactile feedback (the sense of touching a solid object, the resistance force appearing during its activation). Introducing there features (at least, approximate) can improve the immersion effect.

At present, there is a technical mean available that can achieve this goal, namely, VR gloves. This device connects to the VR glasses and performs two-side data exchange. Firstly, the data about current location in space and pose of the hand is collected from sensors and transmitted to the VR glasses. VR software can process this data and draw a 3D model of hand in the correct pose and location with respect to the virtual environment. So that, VR gloves can serve as a controller allowing user point some places of the displayed panorama or perform hands and fingers movements to answer teacher's questions. Secondly, the VR software continuously checks the contacts between the 3D model of hand and the virtual environment; if any, it sends the information about the location and character of the contact to VR gloves. The gloves process this data and activate matching vibrating motors to make the user feeling virtual objects. In total, these features help to correctly perform and remember complex operations, even if they require fine motor skills. This is rather actual for vehicle-related subjects because the panels in vehicle cabins or in mounted equipment are full of diverse buttons, toggles, levers, and other controls.

Yet, there are obstacles hindering wide application of this aid. The functionality for proper displaying the 3D model of hands must be implemented in the used VR software, which is a non-trivial problem. Moreover, the cost of VR gloves is considerable at present. Still, we expect that the advances in the field will facilitate solving these difficulties and make this aid much more feasible in the near future.

5.6 Details of Implementation of VR Simulator

For the implementation of the software part, a tight collaboration between the Institute and IT company "Innovative Distance Learning Systems Limited" was established. The Company developed the viewing software, and the experts of the Company performed photographing the interiors and exteriors of vehicles, fabrication of 360° panoramas, and loading them to the viewing software. The Institute took part in developing the content, carried out approbation, and developed methods for the most efficient application of the product in teaching.

The hardware part was chosen in accordance with the following considerations.

The VR glasses are of two kinds. The first kind comprises a built-in display; such glasses must by connected to a source of video signal, which is usually a computer running VR software. The second kind of glasses is called "VR boxes". There, the role of display is played by a smartphone, which has to be installed (reversibly) into the VR box. In this case, the source of video signal is the same smartphone, which runs VR software.

The teacher's display must be connected either to the computer that generates the image for VR glasses of the first kind, or to the supplementary computer that receives the image from the smartphone installed in VR glasses of the second kind.

The simplest kind of controller is computer mouse: when connected, a cursor is shown on the image, and the trainee is able to move it and set to the needed position (e.g., to the position, at which some control is seen at the moment).

Taking this into account we used the next hardware in our implementation (figure 5):

- a smartphone running Android operating system where VR software is installed and 360° panoramas are uploaded;
- a VR box because it does not require a computer to work, is much cheaper than VR glasses, and still provides the ability to view 360° panoramas;
- a wireless computer mouse as a controller because it is a common and inexpensive device requiring no adaptation for trainees;

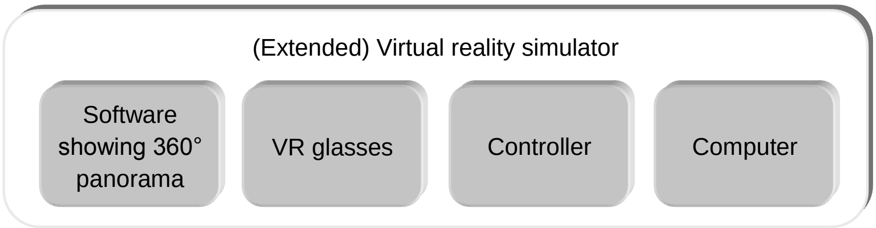

Figure 4: Composition of the proposed virtual reality simulator.

- a laptop running Windows 10 operating system because the needed configuration is relatively simple and the image from VR glasses may be received wirelessly via Miracast technology.

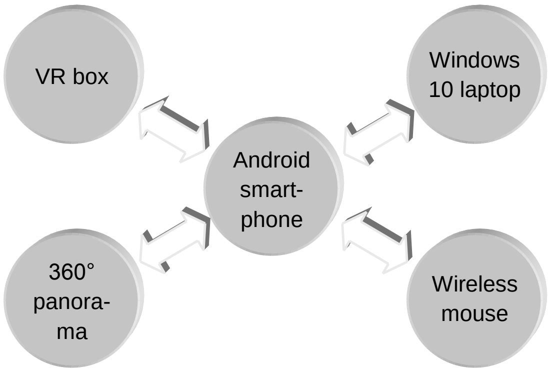

Figure 5: Authors' choice for the hardware implementation of proposed virtual reality simulator.

Considering the extended VR simulator that includes VR gloves as a controller instead of computer mouse, we note that the gloves must meet several requirements to provide the best immersion experience during training:

- complete finger tracking;
- usage of moisture-resistant material;
- tracking the shoulder joints and wrists;
- wireless implementation with low latency;
- vibrating motors for tactile feedback.

Finally, to maximize the immersion experience, the VR software should accompany all trainee's actions on switching on/off the controls by accurate sounds.

5.7 Application in Teaching

The 360° photographic panoramas are well-suited for demonstrating confined premises where all the points of interest (labels, controls, indicators etc.) are located at a similar distance from the viewer. Actually, this is a case for most vehicle cabins and portable equipment, transported by vehicles (e.g. portable chemical laboratories). Therefore, the aid is most suitable for teaching subjects considering the above things.

Considering the financial side, the total price of the aid is very limited (hundred to thousand times less than a price of a single simulator), which makes feasible for educational establishments to obtain the aid. Moreover, the price makes readily possible equipping specialized classes for groups of 10–20 trainees. This option proportionally increases the time a trainee spends in the teaching aid and, thus, further improves teaching quality.

Importantly, the first three aids (360° panorama-based traditional and interactive videos, virtual tours) are ready for use at distance learning, as well. Moreover, we expect that in perspective VR glasses will become even more affordable, and it would be possible for trainees to equip themselves with proposed VR simulators and attend the corresponding classes distantly. This would improve their learning experience even more.

Summarizing, 360° photographic panoramas appear as a multifunctional content that can be turned into a range of teaching aids of different character.

5.8 Test of Effectiveness

In order to test the efficiency of the proposed aids, a teaching experiment was carried out at the Institute. The points #1 "Location and operation rules of controls and indicators" and #2 "Preparation of the vehicle to engine starting-up and movement" of the practice lesson "Training at simulators on preparatory exercise #1" belonging to the credit module "Driving basics" of the subject "Basics of driving combat vehicles" were chosen. The exercise #1 in this module is "Preparation to starting-up and starting-up of the engine" (further called "the exercise"), its procedure contains 19 steps.

The experimental class was held at an experimental multifunctional room. 360° panorama-based teaching videos, virtual tours, and VR simulators were employed. For comparison of efficiency, the reference class on the same lesson was held in a traditional way using common teaching aids (posters, conventional simulators).

Both classes started with learning the general structure of the BTR-4E transporter, its cabins, controls, and exploitation basics. The trainees were provided with the general information about the purpose of the control cabin and the driver operating procedure by means of either posters and textbooks (reference group) or distance course "Structure and exploitation basics of BTR-4E" (experimental group) containing 360° panorama-based teaching videos and virtual tours (dl.khpi.edu.ua, 2020).

Then, the training was continued with the help of either a conventional simulator (in the reference group) or the proposed teaching aid further called "a VR simulator of the driver cabin" (in the experimental group). In the latter case, the procedure was as follows. The teacher divided the group to pairs, and in each pair trainees were assigned with #1 and #2. Then, the following tasks were specified to #1 and #2:

Actions of #1: Help #2 to wear a VR simulator and take a controller. Read the text of the exercise procedure step by step making pauses after each step to allow #2 find the needed control. Check the correctness of #2's actions by watching the laptop, do corresponding notes and write down the results of training into the control sheet.

Actions of #2: Wear a VR simulator and take a controller, repeat the steps read by #1, find the needed control and point it with the controller. Then, pronounce each step of the procedure by memory, find the needed control and point it with the controller.

When the actions were completed the trainees #1 and #2 exchanged their roles.

The success of teaching during the experimental and reference classes was assessed by the results of the next class, when both groups of trainees had to execute the exercise at a conventional BTR-4E simulator. This class has been carried out identically with both groups. The main results are as follows.

The marks for completing the exercise are summarized in table 2. Here, the mark is determined by the consumed time: "excellent", "good", "satisfactory" corresponds to no longer than 1 min 30 sec, 2 min, 2 min 30 sec, respectively. It is seen that both groups have similar distribution of marks that indicates they received equivalent training. This proves that the collection of proposed teaching aids is able to successfully augment the traditional teaching aids and replace full-size simulators in the task of familiarizing trainees with vehicle cabin.

Further, the occupation of the conventional simulator by the experimental group was 4 times lower than by the reference one. Hence, application of the proposed aid allows free substantial amount of the simulator time, which then can be allocated to other classes, which employ full range of its capabilities.

Table 2: The success rates of the two groups of trainees.

	Control group	**Experimental group**
Total trainees	25	25
"Excellent" marks	10 (40%)	11 (44%)
"Good" marks	8 (32%)	6 (24%)
"Satisfactory" marks	7 (28%)	8 (32%)
"Unsatisfactory" marks	—	—

6 CONCLUSIONS

Deficiencies in the available range of teaching aids for vehicle-related subjects, which decrease the teaching quality of the subjects, were identified. Firstly, it is desirable to rise the amount, quality, and technical level of such basic teaching aids as teaching videos. Secondly, there is a high demand for a teaching aid that possesses such feature of the simulators as immersion but is less expensive. Both these deficiencies are proposed to fill by means of an introduced collection of new teaching aids based on 360° photographic panoramas.

Considering the first deficiency, the panoramas can readily serve as a content for making teaching videos, including the H5P interactive ones. Importantly, the process of fabrication and the needed equipment are much simpler than those for traditional posters and videos. In addition, the panoramas themselves act as an interactive teaching aid with functionality inaccessible for traditional posters, drawings, videos that can be naturally integrated into learning management systems like Moodle.

The second deficiency is solved by a teaching aid constituting the 360° photographic panorama viewed in virtual reality glasses. Its main feature is the possibility to provide visual sensation, immersion and motor experiences, which are approaching to the provided by conventional simulators. At the same time, the equipment is rather affordable to obtain by educational establishments, and its usage is straightforward and does not demand special skills.

The efficiency of the aids was proved by a teaching experiment that showed they can serve as an alternative to conventional posters and simulators on the stage of trainee's familiarizing with vehicle cabin appearance.

Summarizing, we think the proposed collection of aids may significantly improve the technology level and cost-efficiency balance of teaching the subjects where vehicles or mobile equipment are considered, and may receive wide application in civil and military education establishments, emergency and military units, enterprises using special equipment. At present, we have completed the 360° photographic panoramas of a series of armored (BM "Oplot", BMP-2, BTR-4E) and emergency (fire engine) vehicles.

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Professional Preparation of Future Teachers of Vocational Training in the Transport Area of Expertise with Use of the Author's Educational Application

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Keywords: Future Teachers of Vocational Training, Vocational Training for the Transport Branch, Electronic Educational Resource, Special Educational Application, Electronic Educational Methodical Complex, Expert Assessment.

Abstract: The paper presents the content, as well as approaches to the use in the educational process of the author's Electronic educational methodical complex (EEMC) "Construction of car". The course is created for students of the speciality 015 Professional education (Transport, the operation and repairing of automobiles). Its content covers general topics including the study of a car engine, electrical equipment and automotive driveline. The created electronic course embraces, in addition to textual material, illustrations, dynamic models, instructions, manuals, textbooks, reference books and glossaries, test material for each topic. Its possibilities of application during lectures, in the course of performing 15 laboratory works, organizing test control of knowledge, as well as for managing students' independent study activities have been shown. Approaches to expert evaluation of the developed electronic study course by 11 criteria have been disclosed. The directions for further improvement of the content and methods of organizing the study and cognitive activity of students when using the course have been highlighted. These include the organization of level assimilation of the material, the creation of an individual educational trajectory of students. A rather high assessment of the developed author's course received from experts allows it to be used in the system of vocational preparation specialists in the transport area of expertise.

1 INTRODUCTION

Nowadays, among all problems, deeply troubling Ukrainian society, there are crucial issues, which concern the educational sphere, its reformation through the prism of perfection and even the fundamental change of approaches towards the study process and the rearing of the young generation. Changes involve all branches of the educational system and particularly the higher pedagogical education.

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The fundamental transformation of contemporary educational space in Ukraine can be characterised by a principally different understanding of objectives and tasks of the high pedagogical education, awareness of the necessity of the switch towards the educational "lifelong learning" model, new conceptual approaches to the elaboration and implementation of innovative methodologies and techniques of efficient educational activity. The current state of experts' of pedagogical specialities preparation including for the vocational (vocational-and-technical) educational institutions conditions the rise of social worrying and preoccupation, as the further development of the educational system, sets the new level of requirements concerning personal and professional qualities of future teaching engineers and involves the finest degree

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of organizational, methodical and didactic support, as well as the application of modern information and communication technologies.

At the present-day stage, the crucial issue of learning of the upcoming generation concerning the usage of the information and communication technologies (ICT) with the objective of a solution of the wide range of actual personal and professional tasks is. The technological stage of scientific and technical progress requires the augmentation of the level of professional preparation of contemporary specialists, as well as the formation of their readiness for the wide application of ICT, that provides the effectiveness of their work in different spheres of human activity.

2 MATERIALS AND METHODS

At the present, ICT occupies a gradually more significant place in the educational system in general and particularly in vocational training. The introduction of computing systems and software tools with a different type of application caused the qualitative progress of the learning process, transforming all its components and extending the cognitive opportunities of its subjects.

Psychological and pedagogical issues of ICT application in the course of the educational process are described in (Bakhmat, 2017; Butcher, 2015; Bykov and Shyshkina, 2018; Denysenko, 2018; Gurevich et al., 2016; Kleiman, 1984; Mashbits, 1988; Orr et al., 2015; Ranieri et al., 2011; Williams and Maclean, 1985; Yashanov and Yashanov, 2017; Zhaldak, 2019; Zhaldak et al., 2021).

The problems of using electronic teaching materials and manuals are widely discussed in (Osadcha et al., 2020; Velychko et al., 2021; Zhenchenko et al., 2020). Certain issues of using electronic learning laboratories and guidelines for students of transport area of expertise were considered by us in our previous studies (Pavlenko et al., 2020; Pohorielov, 2020; Bondarenko, 2018).

The *goal* of the paper is to present the content, approaches to use in the educational process of the author's Electronic educational methodical complex (EEMC) "Construction of car", developed for students of speciality 015 Professional education (Transport, the operation and repairing of automobiles).

3 THEORETICAL BACKGROUND

Before proceeding to the presentation of the main content of the developed authoring software, it should be considering the most important approaches to solving this problem.

UNESCO define ICS as s forms of technology that are used to transmit, store, create, share or exchange information. This broad definition of ICT includes such technologies as: radio, television, video, DVD, telephone (both fixed line and mobile phones), satellite systems, computer and network hardware and software, as well as the equipment and services associated with these technologies, such as video as well as the equipment and services associated with these technologies, such as video conferencing and electronic mail (Wachholz and Meleisea, 2006).

The "modern means of ICT" are interpreted by Robert (Robert, 2014) as programmatic and technical tools and devices, that function on the basis of microprocessing and calculating hardware, and also modern means and systems of informational exchange providing operations of collection, production, accumulation, storage, processing and transmission of information. According to particular researchers' opinion, new educational ICT means can be presented as the assemblage of tools and methods of information working up ensuring purposeful transmission, procession, storage and displaying of the informational product (e. g. data, ideas or knowledge). Additionally, ICT suppose for the application of different technical means, whose most crucial element can be represented as a computer.

It is open educational resources that one of the innovations in the digital educational system of the last decades. The term "open educational resources" or OER uses for denoting educational and scientific resources, which free access or released with authorisation of their usage or modification by third parties. Orr et al. (Orr et al., 2015) highlight the following most characteristic features of open educational resources:

- methodical, educational and scientific orientation of their materials;
- support of different formats and data carriers for the presentation of materials;
- the publication within of the license authorisation of educational and scientific materials, which became the objects of public ownership;
- free access, application, procession and allocation of materials by other users;
- minimal restrictions (or their absence) in the course of work with open educational resources.

Bakhmat (Bakhmat, 2017) considers the idea of the promising study of the issue of the usage of open educational resources in the state of ceaseless development of science and theoretical principles of computerisation of the educational process. From the researcher's fair viewpoint, open educational resources have to unite the sites of all educational institutions and all electronic libraries, as well as provide the system of distance learning and advanced training; they also must have simplified instruments to develop students' IT competency.

Loboda (Loboda, 2012) classified the electronic learning tools as 4 types:

- the first type (the means of theoretical and technological mentoring) are electronic books, computed studying programme, computed system of knowledge assessment;
- the second type (the means of practical mentoring) is electronic task manager, computed trainer, SMART study system;
- the third type (auxiliary means) is computed laboratory workshops, computed reference book, multimedia study classes, service software for educational purpose;
- the fourth type (integrated means) is the computed studying course, the educational electronic resource.

Accordingly, the means of ICT include the hardware and software tools, such as digital devices, local computational networks, equipment performing input and output of information, the tools of archived storage of enormous amount of data, devices for the transformation of information, instruments for manipulation with audiovisual content (multimedia), the modern means for telecommunication performance, SMART systems, instruments of computed graphics, as well as programmatic complex of tools (machine languages, compilers, operational systems, packages of apps, etc.).

As it was indicated before, the application of ICT in the course of educational process realises the following opportunities (Horbatiuk, 2011):

- Firstly, it creates a new specific type of educational activity so-called "developing educational and informational environment", which combines the properties of cognitive, communicative, playing, intellectual, and creative activities.
- Secondly, the use of ICT provides for more complex and profound management of students' cognitive processes.
- Thirdly, the application of ICT leads to the qualitative transformation of students' study and cognitive activity according to contemporary principals, comparing to traditional methods of learning.

According to Verbitsky (Verbitsky, 1991), the introduction of ICT means into the educational process denotes the beginning of the systemic reformation of the complete studying technology, and, what is more important, the fundamental change of activity of subjects of the educational process – teachers and students. The possibility of a computer to display the state of educational activity in signing and symbolic form allows to learn of studying material with the aid of active means of cognitive interaction. The application of simulative capabilities of computers as an instrument provides not only the possibility of transformation of the substantive content to students but also the capacity to deliberately appeal to the bases of their actions, to perform their planning and analysis. This, finally, creates the circumstances for energetic and autonomous modelling by students' activity.

Further, the experience of creating and using an electronic educational complex in the study process will be presented. It combines the existing advantages of modern teaching tools and allows to solve the problem of vocational training specialists in the transport area of expertise.

4 EXPERIENCE OF LEARNING PROCESS ORGANISATION WITH USE OF AUTHORIAL EDUCATIONAL RESOURCES AND APPS

4.1 The Content of the Electronic Course "Construction of Car"

Let us examine the characteristics of realization of the basic types of students' study and cognitive activity with the use of the Electronic educational methodical complex (EEMC) "Construction of car" in the context of the formation of readiness of future teaching engineers in the transport branch for using ICT in their professional activity.

Mastering of study material. During the studying of discipline "Construction of car", students make acquaintance to the appropriation, construction and principle of operation of modern automobiles and learn how to analyse the structure and work of the main parts of vehicle.

By activating the study and methodical module of EEMC, students are granted access to the electronic textbook, whose material is clearly and logically structured according to the content of the educational programme of the course "Construction of car" (figure 1).

As figure 1 shows, the left side of the window contains the list of educational units and topics, whose choice can be performed by pressing the left mouse button on the appropriate title (or name). The result of previous actions to the window of the programme leads to the appearance of necessary educational information, whose perception is greatly facilitated (or extended) with the aid of graphic components, footages, audio tracks, multimedia elements, etc. The upper part of the window of the electronic textbook contains the appropriate icons providing the transition to other components of EEMC (its controlling and diagnostic or informational and exploring modules), the transition to the main window of the software, the exit from the software, as well as the search of demanded information by using the keywords.

Figure 2 illustrates the window of the electronic textbook, which contain the study material from the topic "The general information about the automobile design". Text information is displayed in the window of the electronic textbook (figure 2) and illustrated with the full-colour graphic images (pictures) and complemented with footage to demonstrate the general arrangement of main automobile components.

The availability of additional buttons-icons (""; ""; ""; "") allows students to move on to the appropriate informational resources of EEMC, such as a printed textbook, electronic glossary, pdf-document (the electronic copy of the printed textbook, which contains the homonymic study material), popular Internet resources concerning the topic of car structure, and electronic reference books.

The use of electronic textbook during the professional preparation process on speciality 015 "Professional education (Transport, the operation and repairing of automobiles)" can take place in follow ways:

1) in lecture classes for summarizing or illustration of main ideas of new study material,
2) for the realization of laboratory and research works with the objective of revision of study material and the search of necessary educational information,
3) in the process of students' extracurricular study and cognitive activity for autonomous acquaintance and deepening of professional knowledge, as well as during the preparation for classes (individual, independent and control works), for the composition of reference papers, term papers, qualifying papers, whatsoever).

Execution of laboratory and practical research. Laboratory and practical classes are aimed for revision of study material of the course "Construction of car", the shaping of practical skills and abilities to work with specialised equipment, hardware, computing devices with the appropriate (supplemental) software, the realisation of simple technical calculations and a lot of other interesting things. By working in specially equipped laboratories, cabinets and educational and productive workshops, students perform the tasks, related to the examination of design and principles of operating of main systems, single units and combined components of modern automobiles, particularly crank gear and gas distribution mechanisms of the engine, the systems of lubrication and refrigeration of automobile engines, the system of power supply to gasoline and diesel engines, storage batteries and generators, electric starters, systems of ignition of engines, lighting and signalizing parts, clutches of coupling, speed-change gearboxes and transfer gears, drive axles, carriers of motor-cars, handwheels of automobiles, brake gears, etc.

Dealing with the authorial EEMC "Construction of car", students have the opportunity to activate the special module – "Laboratory training", which contains the system of laboratory and practical tasks, whose execution is compulsory. The course offers 15 topics (they showed in figure 3).

With the activation of the necessary laboratory and practical tasks (by clicking on the appropriate title), the instruction is displayed on the screen. It covers the list of the objectives of the work, the information concerning the material and technical means, which are necessary for the execution of the work, the brief algorithm of steps, the recommended literary resources and the system of control questions. One of the possibilities is shown in figure 4.

In the course of execution of laboratory and practical research, students are authorized to actively use all supplemental means of EEMC, such as electronic reference books, electronic textbooks, informational and exploratory modules, graphic images (drawings, schemas, images, etc.), audio and video files, i.e., everything that demonstrates the specificity of solution the put tasks, preparation of multimedia presentations and other things.

Completion of informational tables, the provision of demanded calculations, the construction of graphical charts and diagrams is realized exactly in the active window of software with the possibility to output the obtained result in a printed form.

The inspection of students' academic achievements. For the realization of the function of pedagogical control the structure of EEMC "Construction of car" provides for the controlling and diagnostic module with the automated system of textual verification

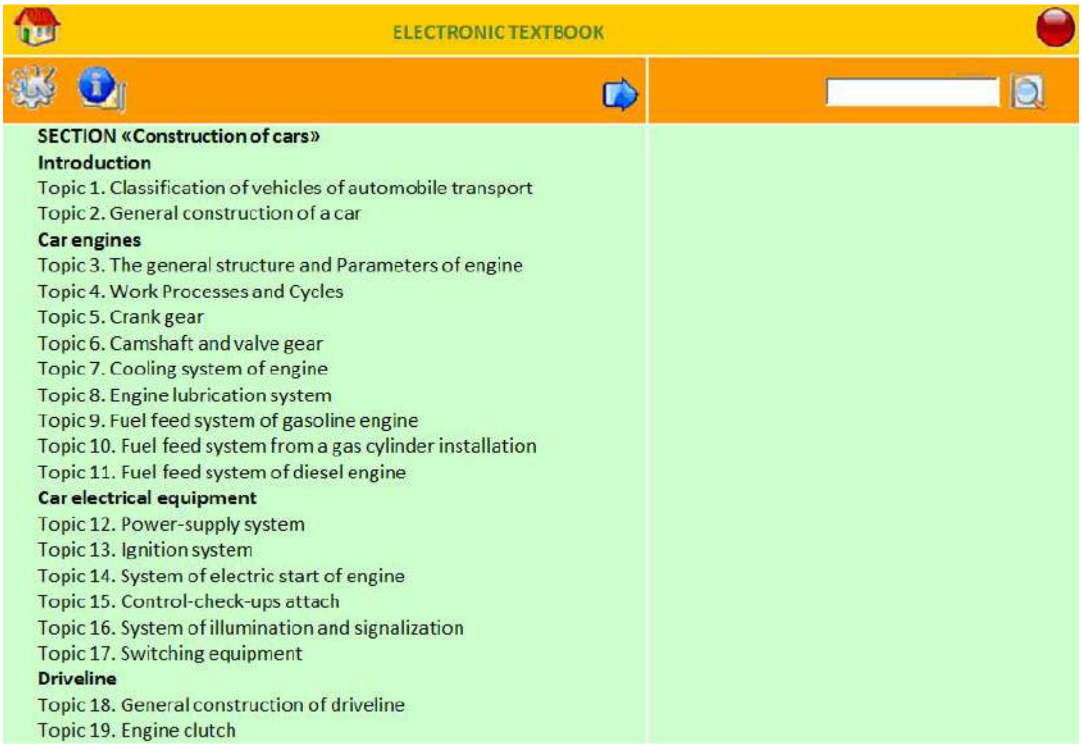

Figure 1: The content of the electronic textbook of EEMC “Construction of car”.

Figure 2: One of the pieces of study information by the course.

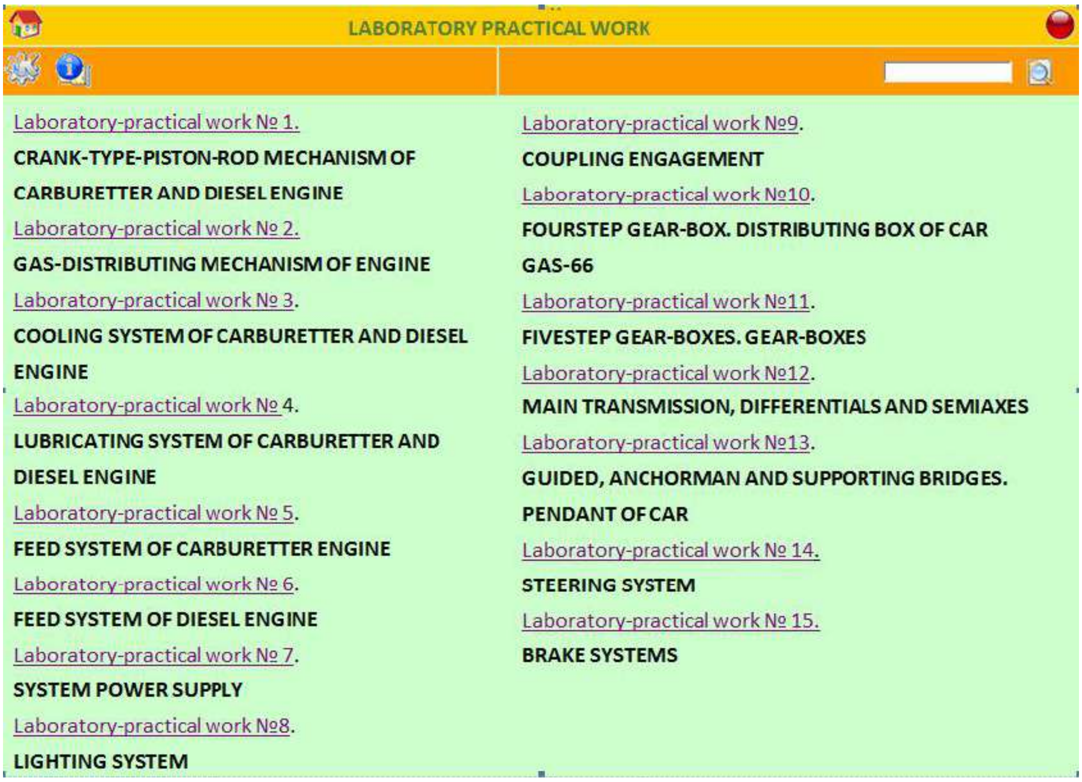

Figure 3: The window of laboratory training part, which contains the list of laboratory works concerning the course.

and the estimation of students' learning outcomes.

The implementation of the automated system of testing inspection allows dealing with different types of tasks (ones with singular and multiple-choice, accordance and ranking tests, ones with open answers) and various degrees of complexity. Work with the "computer tests" is possible at any stage of students' learning, but it is predominantly used for revision of academic achievements and also for the organization and realization of current and summarizing rating of knowledge. With the activation of the automated system of testing inspection user (a student or a lector) acquires the ability to choose the pedagogical test of the appropriate topic of the course "Construction of car" and indicate the aim of testing.

In this case, the following choice is possible:

1. *Preliminary testing* is for the revision of mastering educational information. During the testing, the system displays the message about the correctness (or incorrectness) of the answer and realises the educational function of pedagogical control. The estimation of the completion of the test is not granted and the result of the testing is accessible for all students for its further analysis.

2. *Test-controlling* is for the verification and rating of students' academic achievements concerning the particular topic (or unit). Executing the testing tasks, the system does not notify a user of the correctness (or incorrectness) of submitted answers. After the completion of testing, the message reflecting the result is displayed (a quantity of correctly given answers and solved issues, duration of testing and a mark). Results of the testing are accessible only to a lecturer and are stored on the host-based computer (in case of working within the local network) or on a local PC and become accessible in case of submitting a special password.

The procedure of testing provides for the users' preliminary registration in the system (with the indication of their surname, name, father's name, and a number of their academic group) and acquaintance to the brief instruction concerning the particularities of dealing with the app (with the illustrated forms of testing tasks, the way of choosing the correct option, the duration of testing, the algorithm of estimation of results, etc.).

Figure 5 illustrates the active window of EEMC in the mode "Automated system of testing control", which contains one of the testing tasks concerning the topic "Crank gear mechanism".

As it can see in figure 5 the inferior part of the win-

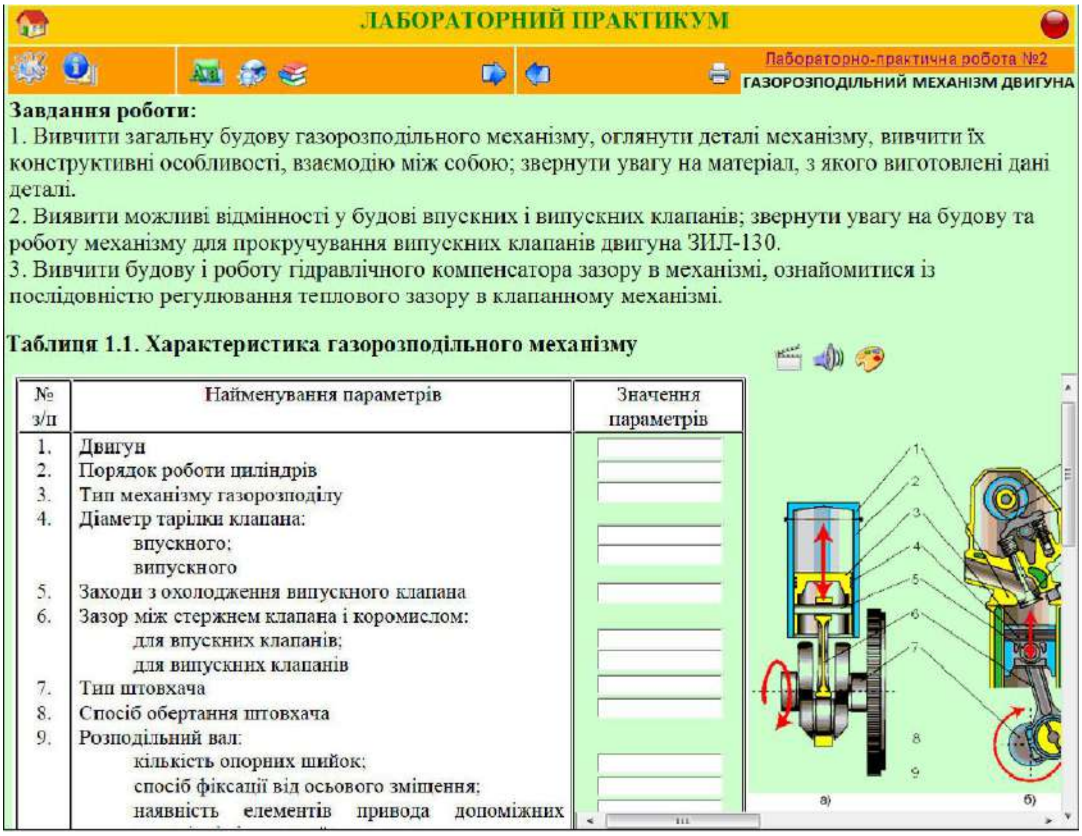

Figure 4: The active window of laboratory work number 2 “Gas distributive mechanism of the engine”.

dow contains the information about the student, the indicated date and time of having the test, the counter of testing tasks with the dynamic scale of fixation of the duration of the completion of the testing event. Additionally, the window of the app covers the special controlling buttons, which allow skipping the current testing task, which will be able repeatedly loaded at the end of a diagnostic procedure, along with the possibility of abruption of the testing procedure by quitting the mode of automated testing control.

Independent study and cognitive activity of students. Organization of autonomous (mentor-led or independent) work can be realized via different modes of interaction with the EEMC. Particularly, the autonomous working up of educational information for some specific topics of the course “Construction of car” by students can be performed with the usage of textbooks, reference books and glossaries in electronic format. The search for some additional information is provided with the usage of accessible internet resources and electronic copies of printed editions in pdf format.

Instructive and methodical materials (recommendation, directions, etc) concerning the usage of EEMC and the execution of illustrated tasks can be viewed by students in the section “Regulatory and procedural materials”. The list of tasks for students’ independent work concerning the material from different units and topics of the course “Construction of car” are given in the homonymous tab of the learning software. Moreover, students are suggested to get acquainted with the list of recommended literary sources (or web sources), which are indispensable for autonomous studying. The information about the execution and formatting of individual tasks and the criteria of their estimation are also mentioned.

Among the individual tasks for students’ independent work, which are presented in EEMC, the following ones need to be highlighted:

- Complex description of appropriation, particularities of construction and operation of mechanisms, systems or integral units of automobiles. Particularly they are a) the overview of the construction of crank-and-rod mechanisms of automotive engines, b) range, type, and properties of oil for lubrication of automotive engines, c) systems of inflation of the engine, and other things.
- Preparation of reference papers on the following suggested topics: “Motorcar factories of

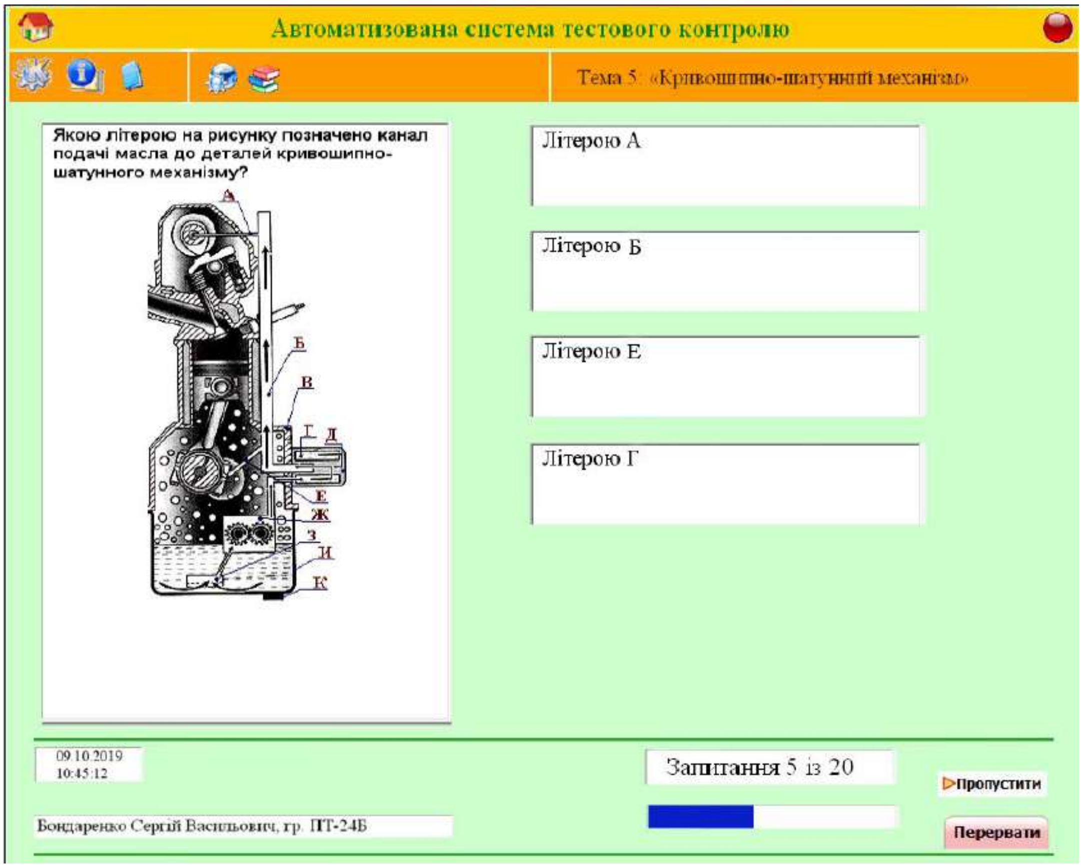

Figure 5: The active window of authorial EEMC in the mode "Automated system of testing control".

Ukraine", "Ignition plugs (their types, construction, marking, particularities of their working)", "Injecting system of L-Jetronic fuel", "Injecting system of Mono-Jetronic fuel", "The system of direct fuel injection", "Motion driveline of all-wheel-drive vehicles", "Antilock braking systems", etc.

- Creation of electronic presentations on some suggested topics: "Appropriation, classification and construction of ignition systems", "Appropriation, classification and construction of friction clutch", "Injection engines nozzles", "Diesel engines nozzles", "Common Rail feeding system", etc.

4.2 Expert Estimation of the Quality of Authorial EEMC "Construction of Car"

Analysis of contemporary scientific and pedagogical literature admits the detection of different approaches towards the rating of the quality of electronic educational editions, including via the researching and experimental, competent or complex type of estimation.

The rating of the quality of the authorial EEMC "Construction of car" was performed by means of the method of competent estimation. In the mentioned case, among the experts, who evaluated the material, were 12 scientific and pedagogical staffs of National Pedagogical Dragomanov University, Ukrainian Engineering Pedagogics Academy, Kryvyi Rih State Pedagogical University leading the classes concerning IT technologies ("The basic computer science", "Information and communication technologies", etc.) and professionally-oriented disciplines, related to transport sphere.

Experts were suggested to estimate the quality of the electronic educational and scientific complex, considering the following criteria:

- Appropriation of vocational preparation of the students to the particularities of the speciality 015 "Professional education (Transport, the operation and repairing of automobiles)".
- The structure of study information.
- The availability of referential informational resources.
- The provision of the students' individual study

trajectory.

- The possibility of the selection of the degree of complexity of study material and testing tasks.
- The availability of tips, instructions, and guidance.
- The possibility of giving feedback in the course of study.
- The availability of the intuitively comprehensible interface.
- The availability of simple means of navigation.
- The facility of using and management of multimedia means and other things.

The quality of electronic educational and methodical complex “Automobile design” was estimated according to every criterion within the range from 1 to 10 points. The general information concerning the estimation of authorial EEMC is displayed in table 1.

The results of the inspection of authorial EEMC “Construction of car” can be considered as reliable ones, only in the case of the availability of the satisfactory degree of coordination (the concordance of all experts’ estimation conclusions), which is characterised the appropriate index of concordance rate W. It can be calculated according to the formula:

$$W = \frac{S}{\frac{1}{12}\left[m^2\left(m^3-n\right)-m\sum\limits_{i=1}^{m}T_i\right]},$$

where n – is the general quantity of estimation criteria ($n = 11$);

m – the general amount of experts ($m = 12$);

S – the total sum of deviation squares of rank sums from the mid score;

T_i – the complementary quantity, that causes the manner of experts’ estimations.

The last index T_i was calculated in line with the formula:

$$T_i = \sum_{l_i=1}^{L}\left(t_i^3 - t_i\right),$$

where L – is the total quantity of groups of the identical experts’ estimations;

t_i – the quantity of the identical estimations of one expert in each group.

In line with the data of table 1, the number of groups of the identical estimations for the first expert is equal to $L = 3$ (the score “10” for criteria 1, 2, 10; score “9” for criteria 4 and 9; the score “7” for criteria 3 and 7).

Therefore, the next formula must be the following one: $t_{1-1} = 3$; $t_{1-2} = 2$; $t_{1-3} = 2$.

Which is consequently equal to follow:

$$T_1 = \left(3^3-3\right)+\left(2^3-2\right)+\left(2^3-2\right) = 24+6+6 = 36.$$

In this way, all amounts of complementary quantity (T) for all 12 experts were calculated.

The total amount of complementary quantity (T) for all 12 experts was equal to:

$$\begin{aligned}T_i = \sum_{l_i=1}^{L}\left(t_i^3 - t_i\right) &= T_1+T_2+T_3+T_4+T_5+T_6+\\ &+T_7+T_8+T_9+T_{10}+T_{11}+T_{12} =\\ &= 36+30+30+30+30+54+\\ &\quad +36+30+36+54+54+30 = 450.\end{aligned}$$

For calculation of the total sum of deviation squares of rank sums from the mid score (S), it is necessary to perform the preliminary calculation of intermediate quantities (table 1), particularly: of the sum of ranks (S_j) for each one of the criteria of estimation, the mid score of the sum of ranks $\left(\overline{X}\right)$, the deviation of the sum of ranks from the mid score (d_j) for each of criteria of the estimation and the square of deviation of the sum of the ranks from the mid score (d_j^2) for each of the criteria of estimation.

All necessary intermediate quantities must be calculated in line with formulas:

$$S_j = \sum_{i=1}^{m} X_{ij}; \qquad \overline{X} = \frac{\sum\limits_{j=1}^{n} S_i}{n}; \qquad d_j = S_j - \overline{X}.$$

Consequently, it can be taken:

$$S = \sum_{j=1}^{n} d_j^2 = 9744.73.$$

Concordance index of the experts was equal to:

$$W = \frac{9744.73}{\frac{1}{12}\left[12^2\left(11^3-11\right)-12\cdot 450\right]} = 0.63.$$

The result confirms the high degree of concordance of all experts’ estimations of the authorial EEMC “Construction of car”.

Obtained index of concordance rate is the random quantity, which involves the necessity of the additional verification of its reliability with the aid of Pearson criterion (χ^2), which is calculated via the formula:

Table 1: The results of the quality estimation of authorial EEMC "Construction of car" by the expert group.

Experts	**Criteria of EEMC estimation**										
	Conformation to the aims of vocational preparation	**Structure of study information**	**The availability of visualization means**	**The availability of referential informational resources**	**The provision of the individual study trajectory**	**The selection of complexity degree of the study material**	**The availability of tips, instructions and guidance**	**The function of giving feedback**	**The availability of the intuitively comprehensible interface**	**The availability of simple means of navigation**	**The management of multimedia tools**
1	10	10	7	9	3	2	7	5	9	10	4
2	10	10	8	10	2	3	7	6	7	9	4
3	9	9	7	10	3	4	8	5	10	10	6
4	10	10	8	9	4	3	7	6	9	10	5
5	10	9	8	10	3	4	7	5	9	10	6
6	9	9	9	10	3	3	7	6	10	10	4
7	10	8	9	9	4	3	8	6	10	10	5
8	10	9	8	10	3	2	7	6	9	10	5
9	9	9	8	10	3	3	7	6	10	10	5
10	10	10	10	9	3	3	8	6	9	9	5
11	10	10	10	9	4	4	7	5	9	9	6
12	10	9	10	8	3	4	7	6	9	10	5
S_j	117	112	102	113	38	38	87	68	110	117	60
$\overline{X}$	87.45										
d_j	29.55	24.55	14.55	25.55	-49.45	-49.45	-0.45	-19.45	22.55	29.55	-27.45
d_j^2	872.93	602.48	211.57	652.57	2445.75	2445.75	0.21	378.48	508.30	872.93	753.75
S	9744.73										

$$\chi^2 = \frac{\sum_{j=1}^{n} d_j^2}{\frac{1}{12}\left[m \cdot n \cdot (n+1) - \frac{1}{n-1}\sum_{i=1}^{m} T_i\right]} =$$

$$= \frac{9744.73}{\frac{1}{12}\left[12 \cdot 11 \cdot (11+1) - \frac{1}{11-1} \cdot 450\right]} = 75.98.$$

The empiric amount of Pearson criterion surpasses the tabular one $\left(\chi_m^2 = 19.68\right)$ for $n-1$ degree of freedom $(12-1=11)$ and credible probability $(p = 0.95)$, which confirms (with a probability of 95%) the nonrandomness of the obtained amount of index of concordance rate and, consequently, the concordance of experts' estimations concerning the quality of the authorial electronic study complex.

The analysis of the data of table 1 certifies the appraising feedback of the experts about the quality of the authorial EEMC "Construction of car" according to the predominant majority of criteria (the mid score for each one of them surpasses 7 points out of the maximal score "10"). Despite that, for four criteria of (1) the selection of complexity degree of the study materials, (2) the provision of the individual study trajectory, (3) the possibility of giving feedback, (4) the facility of using and management of multimedia means and other things, EEMC requires its further refinement and perfection. In this way, authors discover their subsequent studies.

5 CONCLUSIONS

It can be freely stated, that the application of modern ICT, the specified, supplementary, and pedagogical software (particularly EEMC "Construction of car") in the course of professional preparation of the future teachers of vocational training in the transport area of expertise provides the possibility of making the following generalization.

1. The use of ICT in the course of vocational preparation of future teaching engineers encourages the increase of their motivation to learning, particularly, because of the possibility of autonomous choice of the mode of working up with apps, the diversification of types of independent work, thanks to the computed visualisation of the study material.
2. The availability of programmatic means with the educational purposes and the capabilities of the modern computed graphics and various tools of demonstrativeness forms and develops the representational thought of future teaching engineers.
3. The application of pedagogical programmatic means, including EEMC, encourages the shaping of the informational culture of students and their readiness for the wide usage of ICT and tools in their future professional activity.

Developed authorial EEMC "Construction of car" was appraisingly estimated by the experts according to the majority of criteria. Prospects of its further enhancement suppose for the perfection of its following criteria: the possibility of selection of the degree of complexity of study material and testing tasks, the provision of the individual educational trajectory, the possibility of giving feedback during the learning process, the facility of using and management of multimedia tools, and the further approbation of the EEMC.

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Teaching Foreign Language Professional Communication using Augmented Reality Elements

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Keywords: Augmented Reality, AR-Technology, QR Codes, Foreign Language, Communication Skills.

Abstract: The article deals with the analysis of the possibilities of AR-technology application for the development of foreign language professional communication skills when students learn a foreign language (on the example of German). The advantages of using AR-technology in this process are defined, namely: the possibility of involving different channels of information perception, the integrity of the representation of the object under study, and detailing its individual structural elements if necessary, more efficient acquisition of the domain terminological vocabulary, and the development of foreign-language communicative skills. It is shown that QR codes can be easily and affordably used to retrieve information about the object of study from public internet sources. The use of AR elements in the process of learning a foreign language, in the form of virtual excursions, is proposed. The results of a survey of students after the virtual excursions are presented. The technological and didactic requirements for organising vocational foreign language studies using AR-technology have been determined.

1 INTRODUCTION

One of the main tasks of educational institutions at the present stage is the search for new educational technologies that can help increase the efficiency of information assimilation, acquisition of professional knowledge, development of abstract thinking, the search for innovative solutions, etc., which in general should cause qualitative changes in the implementation of the competency-based approach to the organization of the educational process. Undoubtedly, such educational technologies should be based on the use of information technologies, since their potential capabilities are inexhaustible in the processes of cognition of the surrounding world and which today can fundamentally change the traditional approaches to the presentation of learning objects, the ways of their study and research, the mapping of connections in real and virtual dimensions.

There are a number of technologies that can change people's perception of reality: virtual reality (VR), augmented reality (AR), and mixed reality (MR). Virtual reality (VR) represents a designed environment that has nothing to do with the real world at all. Mixed or Hybrid Reality (MR) is a technology that allows the interaction of real and virtual objects to be seen. The difference between augmented reality and other types of reality is that in the case of augmented reality there is a partial replacement of the real world by extending it with a virtual image (Lavrentieva et al., 2020).

Using AR technology allows a person to quickly find and receive information about real objects, which can be represented in any volume and displayed in a symbolic, sound, graphic or animated form.

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In production, AR fundamentally changes the processes of designing and manufacturing technologically complex products, while increasing labour productivity and reducing errors. A special effect, as already shown by the practice of some large companies, is achieved by training personnel or improving their qualifications. In this case, first, timesaving are achieved because employees learn directly during work. In addition, the hint system is more understandable and accessible, since it can provide not only the provision of explanatory information, but even simulate the finished product based on its individual elements. Using such technologies in the professional training of specialists in higher education institutions, we can apply the latest forms of methodological support of the educational process, which will directly accompany the process of cognition and research.

The purpose of the paper is to identify the possibilities of augmented reality technology application for the development of foreign language professional communication skills and abilities of students in learning a foreign language (on the example of German); to set a list of augmented reality elements that can be applied in this process; to develop technological and didactic prerequisites for foreign language learning organization in this way.

2 RESEARCH METHODS

Theoretical analysis of scientific publications on the impact of AR on the educational process, in particular on learning English, allowed us to determine the degree of knowledge of the problem under study and to specify the topic for our research. The descriptive method was appropriate to describe the background, path and results of our research.

An experimental trial was needed to test the effectiveness of using a number of AR elements in the educational process. It involved the participation of students in group work regarding the preparation and direct use of AR elements in German language learning. 39 students took part in a questionnaire survey. The questionnaire contained questions grouped into four blocks: motivational, informative, linguistic and technological.

We used generalisation to draw the most important conclusions from the research conducted and the results obtained.

3 LITERATURE REVIEW

The technology of AR is not only increasingly used in various industries and fields of science, but attempts have already been made to apply it in the educational process. This mainly occurs in foreign universities, and is reflected in a number of publications by scientists. In particular, according to Kaya and Bicen (Kaya and Bicen, 2019), AR applications can be used in almost any educational environment, and their use in the educational process increases the level of students' knowledge.

According to Bower et al. (Bower et al., 2014), AR can cause a profound transformation of modern education. Overlay multimedia on the real world to see via web devices such as phones and tablet devices, means that information can be made available to students at any time and in any place. Scientists believe that this can also reduce students' cognitive overload.

Santos et al. (Santos et al., 2014) identified the benefits of AR technology, which included real annotation, contextual visualization, and haptic visualization. Scientists substantiate these advantages with several latest theories – multimedia learning, experimental learning and the theory of animation visualization.

In the context of our study, the developments of scientists and practical teachers on the use of AR in the study of foreign languages are of particular interest. In particular, Godwin-Jones (Godwin-Jones, 2016) focuses on the links between AR and modern theories of foreign language learning, which emphasize localized, 12 contextual learning and semantic connections with the real world. The researcher considers this possibility using mobile games created using the ARIS platform (AR and Interactive Storytelling), a free open source game editor of the University of Wisconsin. From his point of view, there are various ways for teachers to use the AR, because it is advisable to study the language in connection with expanded digital spaces.

Liu and Tsai (Liu and Tsai, 2013) focused on building written writing skills in English at Taiwan universities using AR through the use of multimedia documents (such as photographs and videos) in the process of learning English with computer support to improve students' language skills, which are necessary for their written assignments (writing an essay).

Akçayır and Akçayır (Akçayır and Akçayır, 2016) investigated the students' attitude to their use of AR applications in learning English, in particular, for learning new vocabulary. According to the results of the study, they found that the technology saves time by simplifying the search for a new word. In addition, AR programs help students remember words. The problem that students encountered during the study, the authors indicated the recognition of the QR code. According to students, the small screens of mobile phones make it difficult to use them in teaching and learning a language.

Considering the search by scientists for ways to intensify the study of foreign languages and the insufficient development of this problem in terms of the use of AR technology in general and in the study of foreign languages, in addition to English, where some attempts have already been made, the question of using AR technology in the process of learning foreign languages is relevant and requires a separate study. In addition, as the analysis of the above works shows, the application of AR technology in the study of English is mainly concentrated on the study of vocabulary, which limits the use of this technology, because its potential is much greater.

4 RESULT AND DISCUSSION

The process of gaining knowledge usually requires the use of different methods and tools for working with information, depending on the technological possibilities and basic didactic and pedagogical models. The development of cognitive didactics has led to the emergence of a new concept of learning, based on taking into account the way people process information. At the same time, the main attention is paid to such cognitive structural and process components of learning as thinking, perception and problem solving. In the process of training aimed at obtaining new knowledge, cognitive structures should change taking into account motivational and affective factors.

When considering the application of augmented reality technology in students' learning of a foreign language in general and in the development of foreign language professional communication skills, we proceeded from the fact that it is necessary to identify and take into account the technological and didactic requirements for organising this type of learning.

As for technological requirements, first it is necessary that each of the students have gadgets to perform tasks with installed, functionally suitable, software to process the AR elements chosen as aids in learning German. A significant obstacle that would make such work difficult or even impossible could be insufficient quality of Internet access. Care should therefore be taken to ensure a stable internet connection. Before planning the use of AR technology in the classroom, the teacher should verify the existence of augmented reality objects on the chosen topic and their availability (free internet access, etc.). In addition, having different options for working with selected objects – real-time, asynchronous timing – will allow the teacher to practise variation in tasks and thus diversify the course.

Providing certain didactic requirements for the inclusion of AR elements is equally important for their effective use in the process of developing foreign language professional communication skills. When it comes to professional communication, it is clear that this involves enriching students' vocabulary with domain-specific terminology. Therefore, one of the didactic requirements is to have a basic knowledge of a foreign language as a basis for students to perform AR technology tasks precisely for the stated purpose. The basic skills of the other field are also needed to engage students in the work envisaged, namely the basic skills of learning a foreign language using Internet resources, on which AR can be built. On the part of the teacher, an atmosphere of immersion in a foreign language environment should be created and strategies for developing productive speech should be provided. This means that the tasks and the organization of the students' work should be designed in such a way as to stimulate the students' independent production of dialogical and monological speech based on the elements of AR. A very important condition for the development of professional communication is the adequate choice of the topic of the session, which should be more or less related to the specialty of the students. The thematic orientation of the content of a particular session, in turn, influences the choice of AR elements. In this context, we also emphasize the careful design of each individual task so that students understand the complexity of speech activity as an integral part of their future professional work.

New technologies, which are becoming more accessible today, contain new didactic potential regarding the possibilities of working with information in the process of studying certain topics (Tarasenko and Amelina, 2020). In particular, the study of a foreign language is impossible without the inclusion in the educational material of linguistic and geographical information related to the country of the language being studied, its traditions, the specific historical or cultural influence of the representatives of this country and the reflection of all these aspects in the students' native country or city. Since it is not always possible to carry out a real excursion to a specific region or to a particular attraction, and sometimes this is impractical due to lack of time, there is the possibility of a virtual excursion that can thematically present the contents of the excursion regardless of time, logistic and human resources. The essence of modern cognitive excursion didactics is the orientation to independent actions, which accelerates the process of acquiring knowledge. In addition, due to its specificity, the excursion has a positive motivating effect (Schmidt et al., 2013). This can increase motivation to learn a foreign language, which ultimately leads to a higher efficiency of learning it.

Based on the above considerations, we chose to create a virtual excursion for German language students as a basic organizational and informational complex. We implemented the use of such a complex in the study of German by students on the example of the topic "Traces of German architects in the history of Kiev". It is worth noting that, since Kyiv is an attractive city for German-speaking tourists, several virtual tours in German have already been developed. In particular, this is the Reisen Kiew project of the Kiewer Stadtführer, which covers the most famous historical monuments of the Ukrainian capital. However, we invited students to consider the outstanding sightseeing objects of the city from a different angle, namely, as indicated in the topic – in terms of the contribution of German architects to their design and construction.

At the initial stage, the selection of objects for a virtual tour was carried out. For this purpose, a number of materials were analyzed regarding historical objects in the territory of the city of Kyiv, as a result of which the following architectural monuments were selected:

1. `St. Volodymyr's Cathedral`. The construction of the cathedral began in 1862 and lasted 40 years. Its construction involved several architects and painters. In 1853-1859, the prominent architect of German origin, Ivan Strom, designed the St. Volodymyr's Cathedral; architects P. Sparro, A. Beretti and V. Nikolaev amended the design. Later, German engineer Berengardt was involved in solving technical problems.
2. `St. Sophia's Cathedral`. The cathedral, built in 1037, was destroyed several times. In 1736–1740, the Ukrainian architect of North German origin, Johann Gottfried Schedel reconstructed the main bell tower. He also built a stone wall around the St. Sophia's Monastery, very successfully combining Western style elements with elements of the Cossack Baroque and folk motifs.
3. `Kyiv Pechersk Lavra`. Until 1745, the architect and engineer Johann Gottfried Schedel worked on the construction of the bell tower of the Kyiv Pechersk Lavra, which became one of the best bell towers in Eastern Europe of the 18th century. Schedel developed a project in a transitional style from baroque to classicism. The bell tower of the Assumption Cathedral was built according to his design in the form of an octagonal four-tier tower with a height of 96.5 meters.
4. `St. Andrew's Church`. The foundations of St. Andrew's Church were built according to the design of J. G. Schedel; however, the design of the temple itself, submitted by him, was not approved. Carved details of the iconostasis, according to sketches and drawings by F.-B. Rastrelli, created by the master (J. Domash, A. Karlovsky, M. Manturov, D. Ustars, H. Oreidah, J. Zunfer), among which there were several Germans. German master Johann Friedrich Grot led installation work.
5. `National Opera of Ukraine`. After the old theater building burned down in 1896, an international architectural competition for the design of a new opera house was announced. More than twenty well-known architects from different countries – Italy, Germany, Russia and France – attended the competition, and the winner was the project of the architect of German-Baltic origin Victor Schröter, a representative of the rational direction of eclecticism in architecture. The new city theater was built from 1898 to 1901 in the style of rationalism, baroque and neo-Romanesque style.
6. `Klov Palace`. The architects J. G. Schedel and P. I. Neyelov built Klov Palace in 1756. The German painter and jeweler Benedict Friedrich performed a number of works, in particular, the painting of the ceiling in the large hall of the Klov Palace. The German garden master Johann Blech worked on the Klovsky garden.
7. `Kyiv Polytechnic Institute`. Famous architects took part in the competition for construction projects at the Polytechnic Institute, including Germans and Austrians, in particular: Benoit, Gauguin, Kitner, Kobelev, Pomerantsev, Tsender and Schröter. The jury recognized the best project of Professor I. S. Kitner, under the motto "Prestissimo" ("Very Fast"). The construction of six university buildings in the Romanesque style began on August 30, 1898 and was completed in 1901.

After determining the content of the future virtual tour, that is, the selection of the outstanding architectural structures of Kyiv associated with the work of German architects, engineers and decoration painters, information resources were identified that students can use to prepare and conduct a virtual tour. Providing students with assistance in information resources was determined, on the one hand, by the desire to reduce the time for them to complete the task, since local history aspects are only part of the German language classes, and, on the other hand, to limit the amount of information for processing by directing it to certain subtopics. In addition, interactivity, a variety of materials and multimedia play an important role in creating a virtual tour. Another important aspect that we were guided by was also the understanding that when integrating information into a virtual tour, we should respect copyrights, that is, use only those sources that are publicly available or those for which a permit is granted.

First, students were offered the job of processing a digital map of Kyiv, since the maps provide an understanding of the integrity of the territory with objects located on it and possible connections between them, form a sense of scale and improve spatial orientation. Using digital maps, students can easily create virtual sightseeing tours, combining sightseeing objects with routes according to certain signs: the chosen topic, the chronological period, the place of a historical event, the sequence of location, the logic of movement. In our study, we used the Google Maps application as a tool for creating a virtual tour map. One of the advantages of this tool is the ability to clearly position the excursion object on the map using built-in search tools based on addresses. Coloured markers were superimposed on automatically identified points on a digital map to conveniently identify each virtual tour object (see figure 1).

The main task of students was to develop their own excursions based on the use of the proposed map. At the same time, each group selects one of the characteristics for building the route. As already noted, the virtual tour was to maximize the achievement of the main goal, in particular, the deepening of the study of the German language by acquaintance with architectural monuments built with the participation of German architects. In this case, the informative part about the objects of the virtual excursion had to combine text, photo and video information into a single, complementary information case, formed using AR technologies. Guided by these requirements, access to the necessary information on mapped architectural monuments should be provided throughout the tour. One of the ways to obtain information, quickly and conveniently, in various forms is the use of modern mobile devices that are capable of reproducing multimedia information concentrated on various web pages. An important issue remains the search for the right information and quick access.

Students were asked to solve this problem by creating a system of QR codes that provide information support for a virtual tour, providing quick access to information about a particular object of the tour in different forms. It is known that a QR code can be generated for textual information, a URL, an e-mail, a phone number, etc., it is easily and stably recognized by special scanners and provides quick access to encoded information.

To this end, students first processed open Internet resources with text, photo and video information about the objects of the excursion, selected the most successful of them, and then, using QR-code generators, formed the corresponding set of codes. An example of a set of QR codes for information about one of such objects of the excursion, the bell tower of the Kyiv Pechersk Lavra, is shown in figure 2.

The main condition for the preparation of textual information was that it should be in German. One of the sources that students used for this purpose was the open electronic encyclopedia Wikipedia (figure 3). This approach had a double effect, since students, on the one hand, processed German sources in the process of searching and selecting the necessary information, and on the other hand, created the opportunity to receive extended information in German about objects during the virtual tour for her ”visitors”, which were students from other groups.

However, for many people, information in the form of a graphic image is more informative than text. In particular, many facts can be presented more fully and clearly in the photograph than in words. Therefore, in a virtual tour the use of images is especially important. In order for the image to be used in a virtual tour, they must be presented in digital form. The range of such images can be very diverse and range from simple photographs to interactive maps, managed panoramic images, 3D images and the like. Image types such as satellite images are also well suited for inclusion in virtual tours. The use of mobile devices in the process of conducting virtual excursions with access to images about the object has significant advantages compared to providing these images in print, primarily due to the possibility of increasing images, changing their brightness and contrast, making even small details visible. When preparing virtual excursions, students sought to provide access through a QR code not to individual images about the object, but to a collection of photographs that would allow them to get the most out of a particular architectural landmark (figure 4). For this purpose, students used the resources of Google Images, Wikiway and the like.

The advantages of video resources are that the presentation of information on the corresponding excursion space is almost realistic and relatively uncomplicated. Like photographs, especially panoramic photographs, films and videos very closely convey the at-

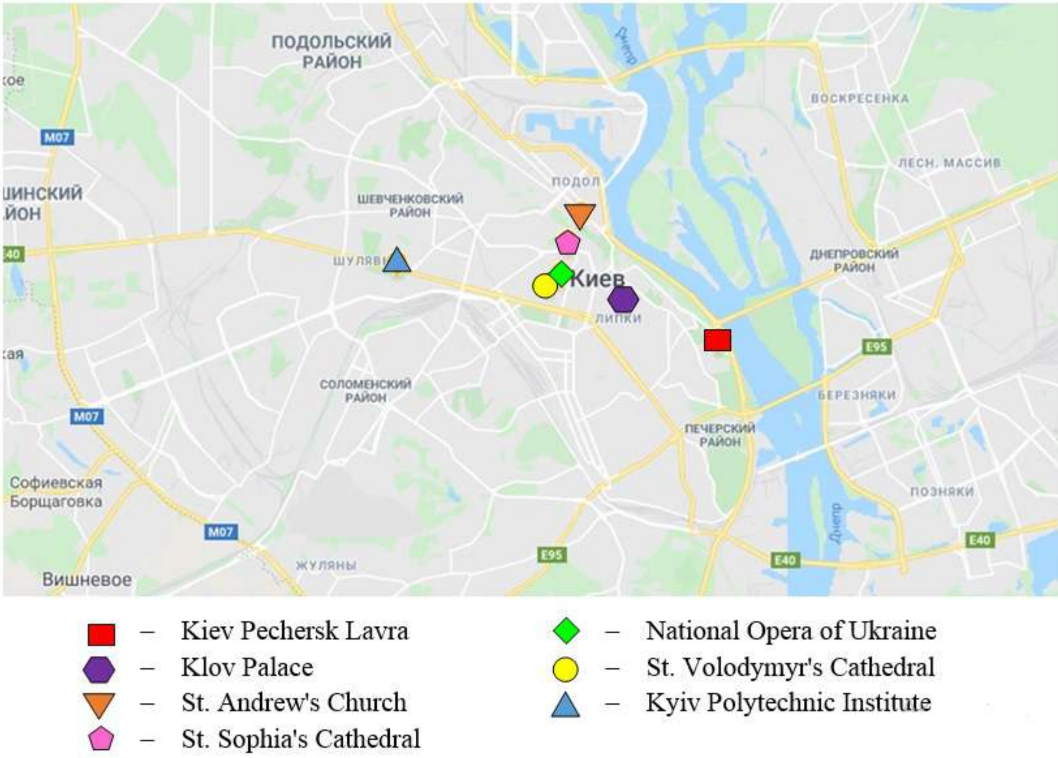

Figure 1: Digital map of Kyiv with printed objects proposed for a virtual tour (Google resource).

Figure 2: A set of QR codes with text (a), graphic (b) and video (c) about the bell tower of the Kyiv Pechersk Lavra.

mosphere of real visits to places of excursion objects. In addition, in the case of using video, there is not only visual perception, but also perception of information by ear.

On this basis, when designing virtual excursions, students integrated thematic films and videos by linking to video portals such as YouTube, Vimeo. An example of a link to the corresponding video fragment encoded by a QR code is shown in figure 5. Topically relevant videos can be quickly found using targeted keyword searches. As with photographs, we also need to respect copyrights regarding videos and films.

It is worth noting that the communication of the group members during the preparation of the virtual tour also contributed to the formation of teamwork skills among students and provided them with the opportunity to develop communication skills in foreign languages. In addition, working together on one topic and intending to achieve a common goal, students learned from each other to build sentences of different types with the correct word order, learned conversational vocabulary options, trained pronunciation of individual words and phrases.

Upon completion of the development of virtual tours of each group, they were tested by students who did not take part in their preparation. After passing these excursions, a questionnaire was proposed, which was aimed at assessing the effectiveness of a virtual excursion with elements of AR in studying the German language. This questionnaire contained questions grouped into four blocks: motivational, informative, linguistic and technological. 39 people attended the survey. The results of the answers to the questionnaire are shown in table 1.

The results of the survey indicate that the use of virtual excursions with elements of AR aroused interest among students, which manifested itself to different degrees and in different aspects when studying the German language. In particular, this approach has most positively affected the substantive aspect of this process. A rather high percentage of students (76.9%) noted that the elements of AR provided them with extended information about the excursion objects presented.

Figure 3: A fragment of a web page with textual information about the bell tower of the Kyiv Pechersk Lavra, access to which is generated by a QR code.

It is gratifying to note that the level of positive answers in the technological unit was also quite high (58.1%), which indicates students' readiness for new forms of organizing the study of a foreign language. However, some aspects of this process caused quite serious technological difficulties. In particular, 61.5% of students were not able to fully use the capabilities of the proposed elements of AR due to insufficient technical characteristics and an inappropriate software set for their own smartphones.

An undoubtedly positive result of using virtual tours is the desire expressed by 79.5% of students to learn German, including in this way. Therefore, it is advisable for teachers to use the influence on the motivation to learn a foreign language, which is created through the use of AR elements in the educational process.

Another confirmation of the advisability of using elements of AR in the study of a foreign language is the low level of positive answers to the questions of the linguistic block of the questionnaire. This indicates that the general level of students' linguistic knowledge is quite low and therefore needs to be improved, including through the search for new approaches and forms of learning a foreign language.

Thus, the use of AR technology contains great potential for the formation of a holistic, realistic view of objects outside the classroom. Owing to the student's independent actions and his emotional impression, when perceiving the educational object, an active approach of the educational content to the student occurs, which leads to better assimilation and longer memorization of knowledge.

Improving the effectiveness of training and longer memorization of the studied content is achieved through higher motivation for learning and active and direct interaction with a real educational object based on AR technology. Since there are different types of students depending on the channel of perception of information (audials, visuals, kinesthetics, mixed types, etc.) (Mayer et al., 2001; Ó Dónaill, 2013; Tarasenko et al., 2020; **?**), thanks to the holistic representation of objects based on AR technology, a higher level of assimilation of educational information and the formation of multicodal representations can be achieved.

One further aspect of our research was to compare the feasibility and relevance of applying other elements of augmented reality technology in addition to the aforementioned ones when students learn German with regard to their field of study. This is due to the desire to optimise the professionalization of German language learning. The most involved in terms of content and thematic content in the information materials and augmented reality technology elements reviewed are the specialities Tourism, Architecture, and History. Regardless of the specialty or specialisation, it is common for them to be able to create models of professional communication in a foreign language, relying on elements of augmented reality. In doing so, we have taken into account that speech activity encompasses more than just linguistic competence. In order to bring training closer to real-life professional situ-

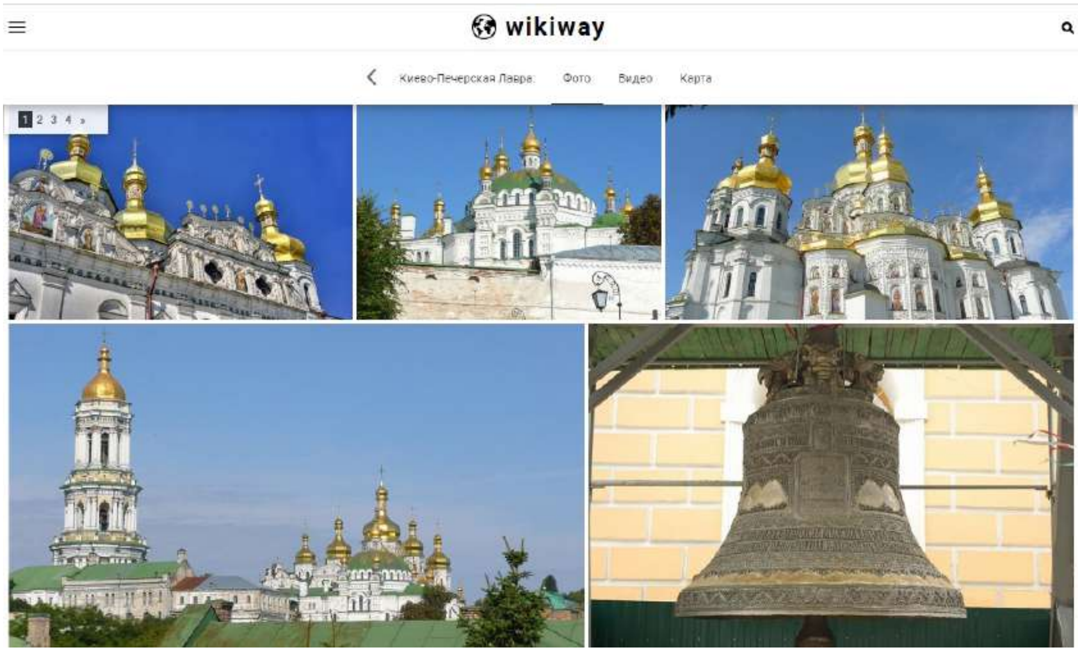

Figure 4: A fragment of a web page with graphic information about the bell tower of the Kyiv Pechersk Lavra, access to which is generated by a QR code.

Figure 5: A fragment of a web page with video information about the bell tower of the Kyiv Pechersk Lavra, access to which is generated by a QR code (Reisen Kiew).

ations, we paid attention to the development of sociolinguistic and pragmatic competence, which can be facilitated by the use of AR technology.

We consider the proposed application of AR technology in the study of German by tourism students to be appropriate for the following reasons. The range of available high-performance mobile devices with integrated cameras allows for the increasing use of AR specifically in the travel industry. Therefore, tourism managers and guides should be trained to not only organise and direct guided tours, but also to prepare and provide virtual tours or virtual demonstrations of individual sites with appropriate descriptions or commentary. Already now, tourists can bring their smartphone to a sightseeing location that interests them and get information about it while walking around the city. Of course, this is possible with a downloaded app. It is to be expected that in the future such services will be extended to foreign tourists, who will purchase individual tours, partly use the services of a guide, and partly act on their own.

The study programme in Architecture includes the history of architecture, construction of buildings and structures, basic design, architectural design, reconstruction and restoration of architectural monuments, and architectural details. For this reason, the study of German in terms of professional communication was built around the vocabulary of these issues. At the same time, the thematic features of the field of architecture are better revealed by studying German with the help of illustrations of architectural structures and their individual details, which can be achieved through AR.

The history specialisation is quite multifaceted. It covers the study of eras, events, commemorative dates and prominent figures in various public spheres. Much of this information, presented through AR, can also be a rational basis for the development of communicative skills, in particular professional communication skills in German.

In addition to the AR elements already discussed above, we also used 3D models in our research, ex-

Table 1: Results of answers to questionnaire questions.

Question	Response rate, %	
	Yes	No
Motivational block	**66.7**	**33.3**
Did the virtual tour contribute to the desire to learn German?	79.5	20.5
Are you ready to continue learning the language this way?	66.7	33.3
Have you been encouraged by the existing elements of AR to depth study of information in German about the excursion objects presented?	53.8	46.2
Content block	**77.8**	**22.2**
Have elements of AR provided you with enhanced information about the excursion objects presented?	76.9	23.1
Did German videos provide understanding of the information about the object of the excursion?	74.4	25.6
Were the text materials sufficient to obtain information on the topic of the tour?	82.1	17.9
Linguistic block	**53.8**	**46.2**
Did the information presented in the form of elements of AR make it easier for you to understand excursion materials in German?	61.5	38.5
Did elements of AR help to understand the meaning of new words in context?	56.4	43.6
Did the augmented reality elements help you remember the terms?	43.6	56.4
Technological block	**58.1**	**41.9**
Were there new ways for you to obtain additional information using QR codes?	71.8	28.2
Have you possessed sufficient skills in using smartphones to receive information presented as elements of AR?	64.1	35.9
Did the specifications and software set of smartphones make it possible to fully utilize the capabilities of the proposed elements of AR?	38.5	61.5

tended to the Tourism, Architecture and History majors. Such photos and videos are a good way of illustrating the learning material. They contribute, on the one hand, to deepening the perception of the object itself and, on the other hand, to immersion in a foreign-language environment (provided there is a text or caption).

We have chosen a 3D model of the famous Pergamon Altar, which is located in the museum of the same name in Berlin, for use in German teaching. Freely available on the Internet, the model provides an overview of this historic architectural monument (figure 6) and makes it possible to see all the desired details clearly, if necessary (figure 7).

Thanks to the different "access points" to the object there is an opportunity to further use the potential of AR to develop both monological and dialogical foreign language communication skills. In order to increase the level of monological communication, we used a number of tasks. Some of them are:

- describe the Pergamon altar as a whole, focusing on its scale, form, construction and material,
- make a suggestion as to the functional purpose of such a structure,

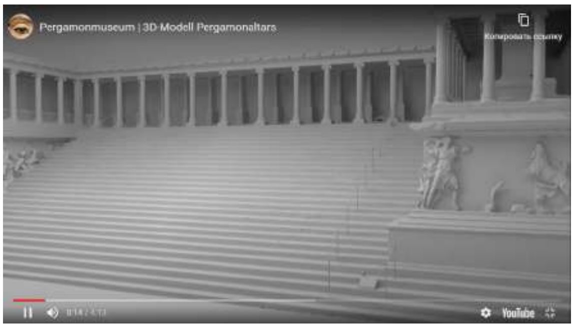

Figure 6: General view of the Pergamon Altar (3D model).

- describe one of the details in more detail,
- to give a German-language demonstration of a 3D model of the Pergamon Altar with clear timing.

We developed the skills of dialogical communication by carrying out, among other things, the following tasks:

- clarify individual details about the Pergamon altar,
- find out the professional opinion of the person you are talking to about this historical landmark,

Figure 7: One part of the Pergamon Altar (3D model).

- discuss the details of the building, presented in the form of a 3D model.

In the organisation of the learning communication based on the 3D model, communicative tools were used, which were made possible by the visualisation of the 3D model. In particular, students exchanged opinions and answered questions by visually highlighting individual elements of the building.

Depending on the educational programme, there were some differences in the results of the tasks. For example, tourism managers were more inclined to produce longer sentences and reactions, but with less specialised vocabulary. The architecture students, on the other hand, paid more attention to architectural details. Their sayings were rich in terminology, detailed, though less so, and their sentences were simple. The history students showed a similar tendency, that is, they constructed their remarks more simply and used quite a lot of terms, but of course, it was from the field of their science.

It is worth noting that the 3D model as an AR element offers access to specially prepared and unchanged information, visualised. Interactive communication in the form of interaction with this type of reality is not foreseen, which limits the development of foreign-language professional communication accordingly.

A positive influence is the activation of the already existing foreign language communication skills, which is achieved in two opposite ways. On the one hand, through the student's relaxed feeling of being in the country whose language he or she is learning. The situation contributes to the student's need to talk. On the other hand, since the duration of viewing augmented reality elements in the form of videos, 3D models, is usually short, it is this time constraint that puts gentle pressure on the student, "pushing" them to engage in the speaking process.

At the same time, the use of the 3D model is possible not only in the classroom but also in students' independent learning. As with other elements of AR, working with the 3D model allowed students to process the task at a comfortable pace, focusing on an aspect, side or detail of the object that is of particular interest or difficulty.

The main problem of using AR technology when learning a foreign language by organizing virtual tours, in our study, as in other cases of using digital information, is the dependence on the technical infrastructure and software. Since each student used his own smartphone with different technical characteristics and his own software set, sometimes this led to problems with receiving and reproducing information in accordance with the used technology. Most of these problems were related to ensuring stable access to the Internet, improper operation of QR scanners and the lack of some software installation skills.

The use of AR technology requires appropriate methodological didactic reorientation, which will create the opportunity for students to independently organize research, collect, evaluate, process and present information, apply complex hypertext structures, develop network thinking, work within flexible, group, project-oriented forms of training.

5 CONCLUSIONS

In the course of the study, a number of advantages of using AR technology in the study of the German language were identified. In our opinion, such advantages can be used in the process of learning other foreign languages, in particular:

We developed the skills of dialogical communication by carrying out, among other things, the following tasks:

- Due to the integrity of the representation of the studied object, the student can get a more complete picture of it, and then learn, for example, a larger amount of new lexical material, since memorizing new words, especially terminology, takes place faster and remains in memory longer when new words are not used in isolation, but in context.
- Based on the application of AR technology, students can familiarize themselves with objects that are unique or inaccessible due to spatial remoteness (for example, are located in another country), which will help them in understanding the essence or purpose of these objects and remembering the vocabulary associated with them, which it would be much more difficult to use other information sources.
- Faster memorization of new vocabulary is also fa-

cilitated by the parallel presentation of information case together with selected objects for study, which allows students to quickly receive extended information using AR technologies.

- The use of AR technology, in particular in the form of a virtual tour, which involves working in a group, allows students to develop communicative foreign language skills.
- AR technology can be a good tool for learning a foreign language, because it allows the student to learn at his own pace. The assimilation of new knowledge and skills takes place based on previous knowledge of the language, the level of which, as shown by pedagogical practice, is very different even within the same academic group.
- Professionalisation of foreign language learning by integrating domain-specific terminology into the relevant language course by illustrating augmented reality objects and their elements.
- The interdisciplinary potential of augmented reality technology, which will make it possible to combine the study of some content aspects of students' future speciality with the study of a foreign language and create the basis for a better career start for young professionals, including in foreign or multicultural environments.

The augmented reality elements that can be used in the process of formation and development of foreign language professional communication skills can be various types of text, graphic and photo/video information integrated into the learning process by using specially generated QR codes as augmented reality tags as well as freely available 3D models.

On the basis of our review of the possibilities of applying AR technology in the process of developing foreign-language professional communication skills, we identified a number of technological and didactic requirements for including AR elements in this process.

Technological requirements include:

- availability of gadgets for students to carry out the tasks,
- the installation by students of the necessary software to process the selected AR item,
- ensuring stable access to the Internet,
- availability and accessibility of augmented reality objects on the chosen item
- possibility to work with these objects both in real-time and asynchronous time mode.

The didactic requirements include:

- basic knowledge of a foreign language as a basis for students to perform tasks on the use of AR technology,
- the formation of basic skills for learning a foreign language using Internet resources, on the basis of which the work with AR can be built,
- organisation of immersion in a foreign language environment,
- using strategies for the development of productive speech,
- thematic orientation of the content from the field of specialisation,
- development of specific tasks for understanding the complexity of speech activity as an integral part of professional functions of a specialist.

Since learning any foreign language in the aspect of developing communicative skills of foreign language professional communication has a number of common features, the results of our study can and should be used in the process of learning other foreign languages as well.

At the same time, in order to better understand the transfer of knowledge through virtual and AR and to be able to develop appropriate methods for using these technologies, further research is needed. In particular, it is advisable to compare augmented and virtual reality technologies with traditional teaching methods and other latest information processing tools, as well as study and compare various methods that offer augmented and virtual reality.

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Using the Augmented/Virtual Reality Technologies to Improve the Health-preserving Competence of a Physical Education Teacher

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Abstract: The article deals with the results of the research aimed at the improvement of methodology of use of augmented reality for the development of health-preserving competence of a Physical Education teacher under conditions of post-graduate education. From the point of Umwelt phenomenology, augmented reality is characterized by correspondence to human nature, its cognitive, metaphoric, diverse, interactive, anthropomorphic nature. The article analyzes the vectors of using augmented reality in the professional activity of a Physical Education teacher, particularly the one that is aimed at health preservation. The software that may be used with this purpose has been described. The positive attitude of Physical Education teachers to the use of the augmented/virtual reality for preserving students' health and development of their motion skills, intellect and creativity was determined in the research. The results of the survey show that the majority of teachers positively react to the idea of using augmented reality in their professional activity. However, in some cases, not a fully formed understanding of this issue was observed. The ways of solving the stated problem could be the inclusion of augmented technologies' techniques into the process of post-graduate education, taking into consideration the anthropological, ethical, cultural contexts as well as teacher involvement in the stated process. Based on the use of augmented/virtual reality technologies, the software application "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching", has been developed, which consists of 5 models. Namely, the virtual models of joints used in order to shape a teacher's understanding of the risks for the locomotor apparatus, which are represented as an anthropological-spatial system. As a result of research of efficiency of application of virtual models as a part of a methodology of development of the health-preserving competence of the Physical Education teachers the positive dynamics of educational results of the Physical Education teachers is defined.

1 INTRODUCTION

The need to use augmented/virtual reality in education (Osadchyi et al., 2020; Striuk et al., 2018; Klochko et al., 2020b; Lavrentieva et al., 2020b; Kramarenko et al., 2020) and, first and foremost, in practices and technologies of Physical Education is caused by its "congruence" to the "human reality", particularly its correspondence to the peculiarities of a pupil's motor activity and the multi-dimensional, adaptable and diverse spectrum of tools that can be used within it. The use of augmented reality in the educational process correlated with the disclosure of the value of human existence and the anthropological-

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value reflection of life-world (Germ. Lebenswelt) (Husserl, 2001) of a person may form developing, intellectual and synergistic effects, which are the manifestation of digital transformation of education and its shift to a new quality level. At the same time, the issue of using augmented reality in the professional work of a Physical Education teacher, namely, for health preservation, is an actively developed topic (Klochko et al., 2020b,a; Hsiao, 2013; Enright et al., 2016). We view the problem of development of a methodology for using augmented reality for the development of a health-preserving competence of a Physical Education teacher in conditions of post-graduate education and on the basis of anthropological (Bollnow, 1971; Fedorets, 2017; Korablova, 2013), ontological (Aleksandrova, 2014) and value paradigms, which includes the need to consider the phenomenology of a person, his/her multidimensionality and the peculiarities of this field of education (of physical culture and sport), creativity and potential of a personality.

Considering the introduction of the augmented reality in an educational process, the necessity of use of ontology-oriented comprehension of a person and his/her motion activity is actualized. In the semantic framework of ontological understanding of a person, he/she is represented as a multidimensional and polyontological creature. Experimental data received by Nosov (Nosov, 1999) and then used by him as the foundation for the development of the virtual psychology, prove the polyontological nature of a person, view the person as place for integration of many realities. Therefore, it is necessary to examine the augmented reality not only traditionally from the "instrumental and technological" point of view but also from ontological positions. In such a case, the augmented reality is considered as a relevant component of person's ontology.

Accordingly, the methodological perception of the possibilities of using augmented reality is carried out with the application of relevant from the point of biosemiotics Umwelt ("the surrounding world") concept (Knyazeva, 2014b; Stella and Kleisner, 2010; von Uexküll, 1909). This concept provides a holistically oriented reflection of a special world or a specific reality of a living organism. The stated reality (Germ. Umwelt), according to von Uexküll (von Uexküll, 1909) is manifested through integration of the world of perception (Germ. Merkwelt) and the world of action (Germ. Wirkwelt) (von Uexküll, 1909). Thus, in the course of its existence, the body forms a "relevant zone", which is that very fragment of reality, which seems to be vitally significant for its perception and activity.

The application of Umwelt conception for the improvement of the use of the augmented reality is a methodologically determined way of ontologization of Homo Educandus (A Person who studies) and humanization of an educational process. Accordingly, the use of an Umwelt idea can extend methodological and technological possibilities of application of the augmented reality by the selection of the special "transitional reality" between a person's reality and the world. Therefore, we suggest to perfect the methodology of use of the augmented reality in professional activity of a Physical Education teacher in the ontology oriented direction, which considerably extends and anthropologizes traditional methodologies and technologies in particular.

In addition, in order to broaden the possibilities of implementation of the existing potentials of the motor and mental spheres of a person, an integrated "external" reality is needed. In this respect, there occurs a need to integrate "corporal", "motor" and "intellectual" realities and "ontologies" (in the sense of reality) of health through the use of an external integrating factor (a "special" reality), which a priori must itself be intelligent. Such an "external reality" within the framework of methodological comprehension presents itself as Umwelt and as the augmented reality.

Accordingly, such an "external" reality must form an intellectualized, dialogic, activity based and intentional (in the sense of targeted) anthropo-technical medium, capable of self-development. A natural precondition of the indicated "corporal and intellectual" integration is the phenomenon of Umwelt, and an artificial one is the augmented reality. Nowadays, such a "new" and "integrating" reality may be formed using digital technologies (Klochko et al., 2020b,a), namely, in the form of augmented reality. The example of the indicated "corporal and intellectual" integration is the use of the augmented reality for the development of emotional intellect of children with disorders of autism spectrum (Chen et al., 2015). In (Chen et al., 2015) the augmented reality was used to teach to recognize mimic patterns. Accordingly, in the indicated cases (Chen et al., 2015), while forming mimic characters there will be present integration of corporal, emotional, intellectual components and an "external" component as the augmented reality.

Thus, we determine the need to use augmented reality in the course of training a Physical Education teacher, particularly, for improving his health-preserving competence (Fedorets, 2017), as a nature-corresponding way of a person's development, which correlates with a person's transcendent and polyontological essence. Augmented reality is a way of integrating the realities already existing in a person (mental, corporal, motor) as well as a way of their improvement. Thus, the application of augmented reality is an end-to-end anthropological project (Klochko et al., 2020b; Aleksandrova, 2014; Savitskaya, 2014), which corresponds to human nature and his/her motor being, and not a "local improvement". Accordingly, in this aspect, the concept of Umwelt can be applied.

Despite a considerable number of studies dedicated to the use of digital technologies and, first of all, of augmented reality in the educational physical culture practices and technologies, the problem of using augmented reality for the development of the health-preserving competence of a Physical Education teacher in conditions of post-graduate education has not been sufficiently studied yet. Particularly, the methodological, pedagogical, anthropological, prognostic and psychological aspects of the stated problem haven't been thoroughly studied. In the methodology of use of the augmented reality, the presence of a "transitional zone" between a person and the world (Umwelt) is not sufficiently taken into account.

Taking into consideration the digital trend of education development and perceiving the practical demand for raising the effectiveness of pupils' health preservation during motor activity, as well as actualizing the issue of education professionalization, pedagogization, digitalization and technologization, the stated research is defined as relevant.

From the point of applying the understanding of a person's Umwelt, an innovation-oriented and integrative use of an image of a person, as well as of specialized biological and medical-biological knowledge, particularly, the comprehension of a locomotor apparatus, is a relevant vector of research. The stated integration may be implemented on the basis of application of the augmented/virtual reality technologies. The application of the stated digital technologies on a new innovative level would facilitate the disclosure of the representative, axiological, health-preserving and intellectual potential of the special knowledge about a person. Such an approach that includes the application of the augmented/virtual reality technologies is aimed at the development of the health-preserving competence of an educator through actualization of value, motivation and technology oriented aspects, linked to a certain system of problems that are of practical significance. Thus, according to the competence paradigm of education, is practically and technologically oriented.

Purpose of the research: the use if the augmented/virtual reality technologies to improve the health-preserving competence of a Physical Education teacher in the course of post-graduate training, which is implemented on the basis of the Umwelt concept, the anthropological paradigm and virtual models of the locomotor apparatus.

2 SELECTION OF METHODS AND DIAGNOSTICS

For the purpose of methodological perception and conceptualization of the possibility and practices of introduction of AR/VR technologies for the improvement of a health-preserving competence of a Physical Education teacher using the Umwelt concept and the anthropological paradigm, the following approaches and concepts, methods and technologies are used: ontological; hermeneutical; axiological; pathopedagogical (Fedorets, 2018); health-preserving (Klochko et al., 2020b,a); phenomenological (Husserl, 2001); life-world (Germ. Lebenswelt) of Husserl (Husserl, 2001); biosemiotic (Millikan, 1984); anthropological (Bollnow, 1971; Fedorets, 2017; Korablova, 2013); anthropological practices and "technologies of self" (Foucault, 1988); Umwelt (von Uexküll, 1909; Knyazeva, 2014b; Stella and Kleisner, 2010); of contact boundary developed in gestalt psychology; of sense making (C. Lorenz) (Knyazeva, 2014b); autopoiesis (Maturana Romesín and Varela, 1984); of embodied mind (Lakoff and Johnson, 2008); of cultural-historical theory of psychic development (Vygotski, 1929); of C. Jung's Self (Germ. Selbst) (Jung, 1916); virtual reality technologies, digital modeling, in particular, 3D modeling (Lavrentieva et al., 2020a); methods of mathematical statistics (Student, 1908). We also used visions and methodological approaches developed in the system of embodied cognitive science (Shapiro, 2007), enactivism (Knyazeva, 2014a) and virtual psychology & virtual science (Nosov, 1999).

For the methodological perception, the following Ancient Greek concepts were used: "human nature" (Ancient Greek φυσιζ του ανθρωπου) (Jaeger, 1986); "harmony" or "mixing" (Ancient Greek κρασιζ) (Jaeger, 1986); "self-perception" (the Delphian principle "Perceive yourself" – gnothi sautou) and "care of self" (epimelēsthai sautou) described in (Foucault, 1988).

To develop the "Methodology of development of the health-preserving competence of a Physical Education teacher based on the knowledge of the nature of the locomotor apparatus in the normal and pathological state" and, accordingly, the pedagogical problems and the above mentioned virtual model we used a complex of approaches: problematic with the help of which we formed the problematic-sensible field and determined the scope of the problem (we determined the area of the unknown as well as the relevant area of cognition) and outlined a system of practically significant problems, situations and phenomena; targeted – defines and specifies the problem and knowledge; competence is aimed at the development of corresponding competences and is reflected in the methodological system; knowledge transfer is used for a selective inclusion into the methodological system (and problems) of medical-biological, anthropological, psychological and other knowledge. Hermeneutic is aimed at the formation of an ability of a teacher to interpret and understand the problematics of health. Axiological approach facilitated the formation of the value component in the pedagogical problems (as well as in the methodology in general) and a relative development of the hierarchal value-conceptual system as a component of the personality-existential component of the health-preserving competence of a Physical Education teacher. The phenomenological (Husserl, 2001) approach is aimed at the selection and consideration of normative and pathological phenomena as well as at the development of a health-preserving intentionality of an educator's consciousness. The ontological approach actualizes the consideration of the issue of health as a manifestation of existence, the corporal ontology manifested in motor activity and body comfort. The anthropological (Bollnow, 1971; Fedorets, 2017; Korablova, 2013) approach is used with the purpose of anthopologization, which includes a holistic and value oriented understanding of a person as an anthropological-cultural as well as a biological phenomenon. The pathopedagogical approach (Fedorets, 2018) is formed on the basis of transfer of medical-biological knowledge aimed at concretization and practical orientation of knowledge through the disclosure of reasons, mechanisms and consequences of ligament and tendon stretching. The holistic approach is aimed at the formation of a complex understanding of a person, namely, in the virtual model we use the anthropic image and not only study concrete problems of joints and tendons. The psychological approach (Nosov, 1999; Jung, 1916) is used in order to psychologize and psychologically perceive the health of the locomotor apparatus and corporality. Systemic, anthropological, pathopedagogical, hermeneutic and axiological approaches are the determining ones for forming the virtual model and problems.

Proceeding from the methodological understanding of peculiarities of the augmented reality as well as Umwelt, we can point out that they are the phenomena that contribute to the formation of meanings, semantic contexts, values, patterns of action, images of health, and semantic images. Therefore, for the expansion of the education-oriented understanding of the augmented reality, we determine the attitude of teachers to the necessity of using the augmented reality for preserving health, development of creativity, intelligence, etc.

In order to determine the attitude of Physical Education teachers towards the idea of using augmented reality in the educational process with the purpose of preserving pupils' health and development of their motor skills, intellect and creativity, we developed a questionnaire that consisted of 6 questions.

The questions of the questionnaire were developed with the prevailing application of the anthropological (Bollnow, 1971; Fedorets, 2017; Korablova, 2013) and psychological (Nosov, 1999; Jung, 1916) approaches. Considering health as an ability to create and a precondition for the disclosure of the intellectual potential of the personality, the questionnaire actualizes the significance of the creative, intellectual, environmental, anticipatory (ability to form forecasts) and other aspects. The questions of the questionnaire cognition, which is presented as an important aspect of health, was viewed from the point of a system of "corporal-cognitive" oriented concepts: the mind-body problem; embodied mind of Lakoff and Johnson (Lakoff and Johnson, 2008); cultural-historical theory of psychic development of Vygotski (Vygotski, 1929) and the methodological approaches developed within the system of the embodied cognitive science (Shapiro, 2007). Thus, in the questions of the questionnaire the motor activity was contextually represented as a component of cognition, which may be actualized at a qualitatively new level thanks to the use of AR/VR technologies.

The respondents were asked to choose one of the three possible answers – "Yes", "No", "Cannot decide". The survey contained 6 questions:

1. Does the use of augmented reality facilitate the development of critical thinking and forecasting (anticipation) skills in pupils aimed at trauma prevention during lessons? ("Yes", "No", "Cannot decide")
2. Can the use of augmented reality facilitate the development of corporality, aesthetic and ethic orientation of a pupil as well as of the competence of self-health preservation? ("Yes", "No", "Cannot decide")
3. Can the use of augmented reality facilitate the formation of ergonomic lessons and the creation of a comfortable, safe and health-preserving environment? ("Yes", "No", "Cannot decide")
4. Can the use of augmented reality facilitate the development of harmonious relations with the en-

vironment, eco-consciousness, implementation of the sustainable development concept and health preservation? (“Yes”, “No”, “Cannot decide”)

5. Can the use of augmented reality facilitate the development of motor skills, creativity, existence and reflection in pupils? (“Yes”, “No”, “Cannot decide”)
6. Can the use of augmented reality facilitate the development of digital and learning competences and intellect (motor intellect, in particular) in pupils? (“Yes”, “No”, “Cannot decide”)

The study used AR/VR technologies to develop a software application “Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching” (CoSpaces Edu, 2021a), which consists of 5 models. To develop and view AR/VR applications, specialized software CoSpaces Edu (CoSpaces Edu, 2021b) is used, which can also be used in the educational process. Software application CoSpaces Edu can be viewed both with the technical equipment for viewing AR/VR applications and in the browser (CoSpaces Edu, 2021b).

To determine the efficiency of the “Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching”, which is an important component of the “Methodology of development of the health-preserving competence of a Physical Education teacher based on the knowledge of the nature of the locomotor apparatus in the normal and pathological state”, we used tests consisting of two problems and four questions. In a somewhat extended form, the stated tasks and questions were also used in the educational process in order to consider the issue of ligament and tendon stretching and tear prevention.

- *Problems*
  1. On stretching the ligamentous apparatus.
  2. On the significance of flexibility developing exercises.
- *Questions*
  1. About the stretching of the spine.
  2. About the risks of deforming osteoarthritis development.
  3. About mechanical energy accumulation in ligamentous and tendons.
  4. About the structural organization of a joint.

The size of the sample n (1) is determined with the help of Student’s t-test (Student, 1908).

$$n = \frac{t^2\sigma^2 N}{\Delta^2 N + t^2\sigma^2}, \tag{1}$$

where:

N is a size of general population;

Δ – the sampling margin of error (permissible deviation from the mean)

$$\Delta = tM;$$

t – the critical value of Student’s t-test, taking into account the number of degrees of freedom $df = N - 1$;

M – the representation error

$$M = \frac{\sigma}{\sqrt{\sum_{i=1}^{3} n_i - 1}};$$

n_i – the number of answers to the i-th question;

σ – the standard deviation is calculated by the following formula

$$\sigma = \sqrt{\frac{\sum_{i=1}^{3}(x_i - \bar{X})^2 n_i}{\sum_{i=1}^{3} n_i}};$$

$\bar{X}$ – the expected value (arithmetic mean)

$$\bar{X} = \frac{\sum_{i=1}^{3} x_i n_i}{\sum_{i=1}^{3} n_i};$$

x_i – the answer option, $(i = 1,2,3)$ ($x_1 = 1$ (no), $x_2 = 2$ (cannot decide), $x_3 = 3$ (yes)).

3 RESULTS AND DISCUSSION

The methodological search was carried out based on the ideas and intentions of integrity, anthropologization (Bollnow, 1971; Fedorets, 2017; Korablova, 2013) and humanization. Thus, the peculiarities of using augmented reality with the aim of improving and implementing the health-preserving competence of the Physical Education teacher in conditions of post-graduate education were studied using the anthropological and biosemiotics approaches (Millikan, 1984).

As of today, augmented reality has become an effective digital learning technology based on the achievements in the sphere of artificial intelligence (Semerikov et al., 2019; Valko and Osadchyi, 2020; Zelinska, 2020); a way of reflection and effective innovative methodology of actualizing emotional intelligence (Chen et al., 2015), intellect, storytelling activities and creativity (Yilmaz and Goktas, 2017), 21st century skills (Klochko et al., 2020a), inclusive education (Alhamdi et al., 2019), interaction of parents with children (Cascales et al., 2013) and potential of a personality.

The issue of using augmented reality in physical culture and sports has been studied by many researchers (Hsiao, 2013; Enright et al., 2016).

While studying the use of augmented reality, we develop the methodological constructs based on the idea of unconditional value of intellect development, creativity and motor activity, which are being implemented due to physical culture. It is based on the fact that it helps the pupil to unveil his/her corporality as well as the mental sphere in the form of a special motor being, as well as through actualization of vitality, life-creativity and sense-creation. Thus, physical culture is a particular motor reality, which corresponds with human nature. Movement and motor being are interrelated with health, which is viewed as an authentic and anthropologically specific way of human existence.

Corporal and motion reality are also the basis of the psychic and mental spheres of a person. According to Vygotski (Vygotski, 1929) (the cultural-historical psychic concept), consciousness is the result of interiorization (in the sense of shifting to the center, into the psychic reality) of the "history" of a person's interaction with the environment. Motor activity occupies the central role in this interaction. At the same time, motor activity lies at the basis of the intellect, both during its formation in ontogenesis (individual development) and during a person's mental activity, as it is in fact a specific motor reality and existence of a human being.

From methodological positions, following the ontological approach, accordingly, we present health, motion and corporealness of a person as special realities. Therefore, they can be purposefully perfected by cooperation with the augmented reality. Meaningful in this aspect is sense-forming and intellectual dimensions of such cooperation. The use of the augmented reality in health-preserving practices of physical culture is the way of opening of motion activity in the formats of intellectual existence.

For the anthropological-value perception of the phenomenon of an intellect as an anthropologically specific reality and ontology (being) it is important to understand that its beginnings and currently relative components lie in the body, corporality and motor activity. This is described by Lakoff and Johnson (Lakoff and Johnson, 2008) in their classical work "Metaphors We Live By". In his embodied cognitive science, Lakoff and Johnson (Lakoff and Johnson, 2008) points out that the notion and metaphors, as system-organizing "elements" of the intellect are primarily formed as corporal phenomena. Currently, embodied cognitive science is developed on the basis of the idea about a close and interdependent connection between the mind, the body and the environment (Stella and Kleisner, 2010).

Schematically, the stated above ideas can be depicted as a sequence of a mutually determined and mutually dependent phenomena, namely: body, motor activity and interaction with the environment – intellect – adaptation, creativity, development. Thus, a person may be viewed as a human being that consists of various ontologies (beings) and realities (Nosov, 1999). And the "way" they are organized into a unity makes the very phenomenon of a person. The stated unity is first and foremost carried out "from within" as this is determined by human nature. According to Jung (Jung, 1916), such unity is perceived by a person as Self, which predominantly is perceived by a personality as the highest harmony of the "internal" God. The idea of a polyontological character of a person is the basis of virtual psychology worked out by Nosov (Nosov, 1999).

Within the framework of the indicated approaches, as well as following the idea of integrity of an organism and the environment and their dynamic cooperation we actualize the question of the use of the conception of Umwelt (Knyazeva, 2014b; Stella and Kleisner, 2010; von Uexküll, 1909) for the improvement of the methodology of use of the augmented reality for the development of health-preserving competence of a physical culture teacher. Umwelt is a special "perception and activity reality" of a living organism.

Thus, the reality is being "fragmented" and "channeled" into a countless number of "parallel" Umwelts "in" which certain biological species live and which they "carry around" with them. This means that the existing reality is multi-dimensional and multi-aspect due to the formation of specific individualized "perception-activity" worlds – Umwelts.

Thus, every biological species generates, masters, sees and somehow understands and interprets the specific and significant for him/her personally spectrum of phenomena, which together form Umwelts. According to Husserl (Husserl, 2001), we comprehend being through perception of relevant phenomena, which together reflect the reality in one's consciousness. That's why, in the context relevant to our problematics, we may speak about the peculiarities of the living world (Germ. Lebenswelt) (Husserl, 2001), which is formed through a person's unveiling, perceiving and using the significant for him/her phenomena. In comparison we should note that apart from Human, other biological species have quite a limited number of phenomena that form their worlds and are presented and "narrowly" specific. These are the worlds of perception, action, being, which primarily define the mode of existence. Quite strictly determined combinations of specific phenomena form the Umwelts of biological species. Thus, all the biological species except for humans are maximally adapted to "their" Umwelts.

Limitation in space and time of animals' Umwelt is pointed out by Stella and Kleisner (Stella and Kleisner, 2010). At the same time, when an animal is transferred to a different environment the stated adaptation possibilities drastically decrease and it is not always possible to for "new" Umwelts, even when resources are available. In essence, living organisms form, support and "carry around" a certain fragment of the reality, which is desired and to a considerable extent set for them. Thanks to the use of the Umwelt concept, subjectivity and personalized differences are actualized alongside with the significance of species peculiarities (Knyazeva, 2014b). Every biological species, including man, has their own Umwelt.

Analyzing the Umwelt concept, Knyazeva (Knyazeva, 2014b) singles out some aspects that are significant for our methodology: active influence on the environment; feedback between the environment and the creature; selectivity of perception and action; sense making; existence of a dynamic boundary between a creature and the environment; interactive unity of the environment and the organism.

Clarifying the importance of the formative specificity of the Umwelt (Knyazeva, 2014b) as a manifestation of life that is related to the semantic potential of augmented reality. Umwelt as well as augmented reality can thus be regarded as environments (or worlds) of forming meanings and ways of using them.

Concerning Umwelt, this is analyzed by the ethologist Conrad Lorenz (Knyazeva, 2014b). That is, through the mind-body, the living organism acquires meaning (living is sense making) (Knyazeva, 2014b), which can be modified and enhanced or weakened by the use of augmented reality. The semantic sphere of man, in turn, is connected with life, existence, images and symbolic reality. Therefore, the Umwelt is the living condition or "transient" fragment of reality that contextually integrates or correlates (according to the concept of autopoiesis by Maturana Romesín and Varela (Maturana Romesín and Varela, 1984)) life is represented as existence, as a given and semiotic-symbolic systems (Knyazeva, 2014a). On the other hand, semiotic systems are formed and exist precisely because of the specific formation of the Umwelt, which is a transition zone or a contact boundary between man and environment. These effects can to some extent be achieved through the use of augmented reality, which we consider as a component of the mind of the modern man or as a way to compensate for disturbed natural connections with the environment and by forming new ones. Similar understandings of the significance of boundary phenomena exist in Gestalt psychology in a system that is considered by the psyche as the contact line between a person and a significant problem. Therefore, one can say, metaphorically: whoever controls the Umwelt shapes meaning and influences life. To a large extent, such an impact can be realized through the use of augmented reality.

Human Umwelts are qualitatively different from other living beings. Man, in the course of its development has created a special environment that at this stage of its existence and development becomes cognitive and cognitive-semantic. The Umwelt created by man actively interacts with it, forming communicative-semantic and cognitive contexts and essentially "communicates" with it. No wonder some creative people point out that the environment "speaks" to them and they take ideas and forces from it. As a specific feature of a person, we distinguish his ability to form "cognitively oriented" Umwelts. In this context it can be stated that by means of professionally made advertising it is possible to form a "digistic Umwelt" through which it is possible to "easily" gain 10 kg of body weight. Accordingly, through the use of physical culture and augmented reality, which will form the "Umwelt of movement", this process can be reversed.

Let us present the methodologically and technologically significant characteristics of the human Umwelt: historicism; cognitive, that is, it is an environment in which data is partially processed and information and knowledge are contained; aesthetism (even the presence of anti-aesthetic tendencies is the antithesis of illuminating aesthetism); ethics (or anti-ethics); value character (in animals we can mostly talk about the hierarchy of needs and importance); dynamism; anthropomorphism; ergonomics; comfort; interpretability; speech characteristic; anticipation (predictive) nature and predictability; ecology (nowadays); promoting sustainable development (at this stage of humanity's existence); harmony; educational; semiotic; digital (currently); health-saving; humorous (only human inherent humor); existential – as open, independent and self-sufficient being; multidimensionality; developmental and creative character; polyontological character; psychologically significant; technological and technical; characterization of relative autonomy. Our understanding of the human Umwelt is close to the concept of the life-world (Germ. Lebenswelt) by Husserl (Husserl, 2001). That is, we do not reduce a human's Umwelt to a perceptual-activity phenomenon, but understand it a little more broadly – based on the allocation of relatively autonomous other components or spheres. For example, training, technology, creativity and more. This understanding of the human Umwelt is also based on an understanding of the as yet undiscovered potential of using augmented reality and digital technologies in general. Based on a methodologically and technologically oriented understanding of the phenomenology of the human Umwelt, we interpret it as a significant multidimensional cognitive and meaningful human reality that has a degree of autonomy and significant contextual impact on humans. Based on the selected characteristics of the human Umwelt, a questionnaire was developed for physical education teachers.

We consider it expedient to use purposefully or at least take into account the phenomenology of human Umwelt when designing and implementing augmented reality technologies. That is, the construction of augmented reality can be carried out not only on the basis of effective target, needy, technological methodological installations, but also taking into account the "transition zone" between man and the world – Umwelt. Digital technologies and approaches that take into account the phenomenology of Umwelt, we call Umwelt oriented. Accordingly, augmented reality can be shaped as Umwelt-oriented. The peculiarity of such technologies will be primarily the use of non-direct influences, cognitive, metaphorical, contextual, spatial, temporal, variability, interactivity, anthropomorphism, individual orientation and other characteristics that reflect the specificity of a person and his mind. This approach is contextually existent and is still being implemented mostly intuitively. In order to maintain health and improve motor activity, the importance of this Umwelt oriented approach is relevant because movement and health are, in so far as they are, contextual values. Movement and health are completely shifted to the actual area of consciousness when a person has certain problems, risks and threats.

Augmented reality allows you to "delicately" create "mental health", "mental movement", "mental health and comfort" and more. Thanks to the use of the augmented reality, we can create "tactfully" the "Umwelt of health", "Umwelt of motion", "Umwelt of safety and comfort", etc.

The indicated Umwelts are a special-purpose transformation or one of possible variants of a person's Umwelt. The purposeful Umwelt formation with desired qualities is a human specific that, first of all, can be exposed due to the use of the augmented reality.

Considering the "multichannel" of human perception, it can be noted that the actual component of "human Umwelts" that can be formed on the basis of augmented reality is their "ability" to synthesize different sensory modalities, namely, sound, visual, tactile, motor. We represent this as a "cognitive-environment synthesis" that facilitates the discovery of humans as beings of "cognitive-motor", intellectual, creative and polypotent. Similar synthesis occurs in associative areas of the cerebral cortex. Artists dreamed of such a synthesis, namely of union, music, light, visual images, movement, movements, odors, touches (Kagan, 1972). This is partly embodied in contemporary art. Thus, augmented reality opens up new and special possibilities for a "new cognitive synthesis". For physical culture, the use of augmented reality, considered in relation to the preservation of health, opens up innovative perspectives, which are first and foremost related to the intellectualization of motor activity and to the ergonomic and natural disclosure of the potentials of man, in particular motor, physical, cognitive, creative.

The actual contemporary direction that gives the opportunity to consider augmented reality and Umwelt as an "active" "cognitive-activity" reality is the concept of autopoiesis by Maturana Romesín and Varela (Maturana Romesín and Varela, 1984). Within the semantic sense of this concept, the phenomenon of life, including the interaction of the organism with the environment, is presented as an active autopoiesis and cognitive process. Also significant is the trend of enactivism (Knyazeva, 2014a), in which the mind-body problem (Knyazeva, 2014a,b). The body and consciousness in this system of ideas are understood in a holistic way. Defining in this aspect are also the ideas of Embodied Cognitive Science (Shapiro, 2007). In the system of this direction, cognitive is represented as a phenomenon that is formed by the interaction of consciousness, body and environment. The notion of cognition as a physical and environmental phenomenon is significant for the professional activity of a physical education teacher, because it works primarily with interdependent phenomena – movement, body, health, which exist in a particular reality and form it. The above ideas about Umwelt and the concepts of autopoiesis, enactivism and embodied cognitivism are considered as aspects that contribute to the introduction of augmented reality, defining the latest understanding of physical culture and sports as "body-cognitive-environmental" and "health-protective" not only as a traditional de-

Figure 1: Organizing specialized online training using SGM SPORTS (SGM Educational Solutions, 2020).

velopment of strength, endurance, or other qualities. The key in these cognitively oriented interpretations of motor activity is the phenomenon of augmented reality as one of the "paths" of the autopoiesis of a person. Similar notions of bodily, motor, and mental perfection existed in the system of the Hellenistic tradition of the paidae (Greek Παιδεια) (Jaeger, 1986) and were realized through "taking care of themselves" (Foucault, 1988) and "self-knowledge" (Foucault, 1988). Thus, through the use of augmented reality, we actualize the development of physical culture as a "body-cognitive" and health-saving anthropopractic and promote intellectual activity of motor activity.

Here are some avenues of using augmented reality for the purpose of developing health-preserving and professional competences for physical education teachers:

1. To watch sports on video or visit the stadium. For example, overlaying content with real-time commentary or recording of a given sport or team player, in particular using face recognition technology and more (figure 1).
2. View matches and training while recording. Here, it is possible to overlay video comments, discussions, graphics, graphic analysis on video; such as displaying trajectories, etc.
3. For training and sports, rehabilitation, inclusion. For example, analysis of data on individual stages of training, displaying the strengths and weaknesses of students in this process, overlay training videos, graphics, comments, realistic 3D simulations, organizing discussions in real time, evaluation of the training session, etc. (figure 2).
4. Development of training videos using augmented reality: commenting on individual stages of training, monitoring the functioning of individual body systems during appropriate physical activities, graphical analysis, discussions, displaying trajectories, etc.

Figure 2: Organization of individual training using SGM SPORTS (Brainshuttle™.experience, 2016).

5. Educational marketing. For example, advertising an educational institution, developing links to your own training courses and training sessions, site pages, programs, and links to other pages of academics, coaches, athletes, clubs, and more.
6. Techno sport. The combination of augmented reality and the physical movement of a player, such as competing with a virtual sport tool (this use is less traumatic than real competition).
7. Simulation of sports competitions: conducting competitions and trainings, graphical analysis, discussions, help, comments, etc.

The use of augmented reality increases the motivation of physical culture teachers to master the complex of professional knowledge, promotes the humanization of the educational process, develops intellectual, emotional and volitional spheres, improves critical thinking, promotes professional reflection of practical experience. It is also aimed at the development of professional subjectivity, the discovery of sports talents, the improvement of sports equipment, the regulation of the volume and intensity of physical activity according to the state of health, etc. Considering all the advantages of this technology, it should be noted that it cannot completely replace the traditional technologies of organization of the educational process and will be the most effective in combination with them.

Consider software that implements augmented reality technologies that can be used in physical education. That software contributes to the formation of "human Umwelt". The specificity of "human Umwelt" is the preservation of health, in particular, through physical activity. Opportunities for augmented reality make it possible to build a trajectory of learning according to individual requirements and needs, and immersion in the audiovisual space makes the theoretical learning experience interesting, engaging and motivating students.

SGM SPORTS by SGM Solutions & Global Media GmbH is designed to organize specialized online training (SGM Educational Solutions, 2020) (figures 1, 2). The basic idea behind this product is learning to generate sports strategies through augmented reality experiences. One of the company's products is a prototype ARVolley volleyball strategy that can be downloaded for free and used on Android and iOS platforms. The program demonstrates and explains the attack numbering system. With it, you can place a virtual interactive playground on the table. These tools are implemented using virtual and augmented environments .experience from brainshuttle™.experience (Brainshuttle™.experience, 2016). Immersing students in the augmented reality environment of brainshuttle™.experience with realistic simulations, activates them in the learning process, exploring their own opportunities at an individual pace. Depending on the actions, students' situations and outcomes change dynamically, supporting the student to actively engage and achieve learning outcomes. With realistic simulation, the student perceives and performs the task at any level. Playing situations of realistic simulations can teach students some maneuvers, understanding of complex games, which can also help prevent injury.

brainshuttle™.experience augmented reality environments are created using 3D video, 360 degree video, Combined 3D and 360 degree video, 3D animation, Virtual environments, Game environments, Augmented environments (3D video, 360 degree video, Combined 3D and 360 Degree Video, 3D Animation, Virtual Environments, Game Environments, Enhanced Environments) (Brainshuttle™.experience, 2016).

DribbleUp offers software based on Augmented Reality Basketball (Smart Basketball), Soccer (Smart Soccer Ball), Health Gymnastics with a Ball (Smart Medicine Ball) (DribbleUp, 2020a,b,c; Meleap, 2020) (figures 3, 4, 5): DribbleUp add-ons are designed for both phone and tablet. DribbleUp products provide the ability to work with a virtual trainer, track the accuracy of the exercises performed, train muscle memory, track workouts over time. DribbleUp Smart Ball allows you to combine different cardio-strength exercises.

For techno sports (a new HADO sport format that combines augmented reality with players' physical movement) from Japanese company Meleap Inc. developed hardware and software based on augmented reality (Meleap, 2020) (figure 6). To play the game, players must also wear a motion sensor and specially designed HMD to track virtual balls and other players. This integration of augmented reality into sports adds

Figure 3: DribbleUp: Smart Basketball (DribbleUp, 2020a).

Figure 4: DribbleUp: Smart Soccer Ball (DribbleUp, 2020c).

magical effects in a normal game, is health-friendly and prevents injury.

In order to determine the attitude of physical culture teachers to the use of augmented reality in the educational process, a survey was conducted by 36 Physical Education teachers. The research was conducted in 2017–2018 at Drohobych Ivan Franko Pedagogical University, Sumy Institute of Postgraduate Pedagogical Education, Mykolayiv Institute of Postgraduate Pedagogical Education. The results obtained are presented in figure 7 and figure 8.

Having analyzed the results of the survey we can note that the majority of teachers (57%) have a positive attitude towards this issue, 18% of the teachers demonstrate negative perception of the idea and 25% were not able to provide a definite answer. Such response distribution within the survey may be caused by the fact that the teachers are not sufficiently informed about the potential possibilities, opened by the use of augmented reality in the educational process.

The analysis of the structure of the answers, provided by Physical Education teachers in the questionnaires shows that so far, the teachers do not fully understand the possibilities of augmented reality in forming ethical attitudes of the health-preserving en-

Figure 5: DribbleUp: Smart Medicine Ball (DribbleUp, 2020b).

Figure 6: HADO Game Using Means by Meleap Inc. (Meleap, 2020).

vironment, eco-consciousness, comfort. This means that Physical Education teachers do not fully understand the sense-forming, contextual and environmental influences of augmented reality.

The ways of solving the stated problem may include the inclusion of augmented reality technologies into the process of post-graduate education taking into consideration the anthropological, ethical, cultural contexts and using the competence based and personally-oriented paradigms; the involvement of Physical Education teachers to the development of educational software applications using augmented reality technologies in the role of consultants, coaches, experts etc.; improving the knowledge and skills of Physical Education teachers on concrete issues and phenomena related to health preservation; involvement of Physical Education teachers into the project work on introduction of the software that includes augmented reality.

Let us consider the example of applying virtual reality in order to develop a Physical Education teacher's practically oriented knowledge about the structure (morphology) and functioning (physiology) of the locomotor apparatus and the cognitive schemes, intentions (aspirations of consciousness) and technological values that are formed afterwards. When inte-

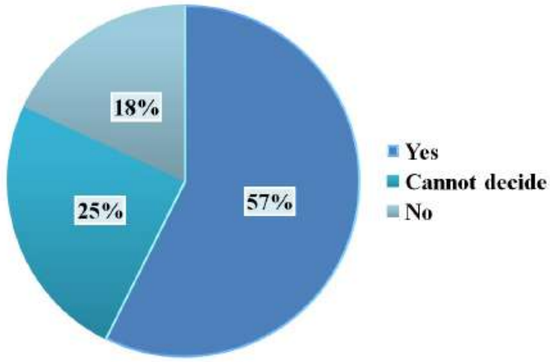
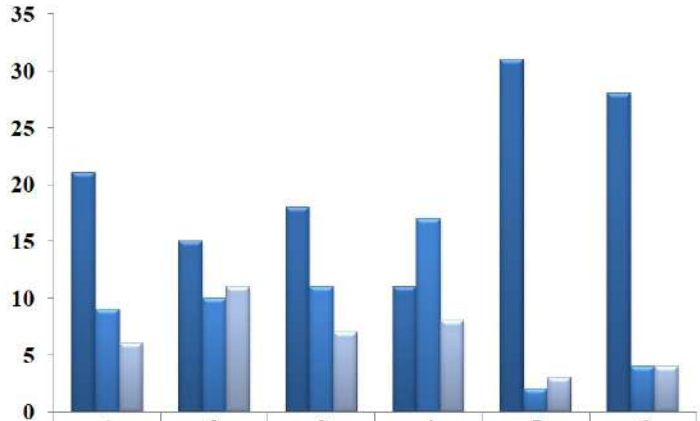


Figure 7: Percentage distribution of responses of physical education teachers by the criterion of their attitude to the use of augmented reality in the educational process to preserve the health of students and develop their motor skills, intelligence and creativity.

riorized (in the sense of transferring to the inside), the stated knowledge, cognitive schemes and values facilitate the development of competence oriented "instrumental" intellectual capabilities of a Physical Education teacher. We believe that such intellectual-value capabilities include conceptualization, understanding, interpretation, reflection and creative health oriented perception of certain pedagogical situations, motion activities and mobility modes based on specialized knowledge about human nature (in this case, an comprehension of syndesmology, the science of bone connections). Together, the stated mental phenomena form a health-preserving way of thinking, which is a significant and system-organizing component of the intellectual-value (cognitive) component of the health-preserving competence of a Physical Education teacher.

According to the global "ideology" of professionalization, in order to effectively preserve pupils' health during motor activities, a teacher should understand the fine, "intimate" mechanisms of the locomotor apparatus functioning. First of all, it concerns the system of connections between the bones, which is represented by joints, semi-joints and other anatomical structures. The central professional-value orientation, aimed at helping an educator master the above mentioned knowledge and interpretation of the joints' phenomenology, is the problem of preserving the health of the locomotor apparatus due to teacher's understanding of the morphological and physiological risk factors and restrictions that need to be taken into consideration while planning motion activity. If the educator does not take into consideration the peculiarities of human morphology and physiology, which are represented as risk factors for pathology development, this may lead to pupil trauma and decrease of the efficiency of the training process.



	1	2	3	4	5	6
Yes	21	15	18	11	31	28
Cannot decide	9	10	11	17	2	4
No	6	11	7	8	3	4

Figure 8: Visualization of the structure of physical education teachers, responses to the questionnaire aimed at determining attitudes toward the use of augmented reality in the educational process to preserve students, health and develop their motor skills, intelligence and creativity (see questionnaire in "Selection of methods and diagnostics").

This pedagogical system studies and analyses in detail the peculiarities of the locomotor apparatus in the normal state as well as in the state of possible pathology, which may occur due to non-physiological (in the sense of being unnatural) functioning of the joints during motor activity.

In this pedagogical system the developed "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching" was used as a teaching method. This model is also a part of the set of tools of the "Methodology of development of the health-preserving competence of a Physical Education teacher based on the knowledge of the nature of the locomotor apparatus in the normal and pathological state". The basis of the stated methodology is the use of pedagogical problems and discussion of practically significant situations, issues and anthropological phenomena, which disclose the nature of the locomotor apparatus in the normal and pathological state as well as presents the possibilities for risk management in order to ensure the health of this system. The stated virtual model is applied while solving the problems for the analysis of the relevant issues and situations.

According to the developed "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching" software application, which in its turn consists of 5 models, which disclose the phenomenology of a joint in a normal as well as pathological state. The conceptual-methodological basis of this model were formed by the ideas of Maturana Romesín and Varela (Maturana Romesín and Varela, 1984), who believed that life is a cognitive autopoetic process, as well as theory about the functional systems by Anokhin (Anokhin, 1968) (Sudakov, 2011), by syndesmology – is the science of ligaments, the pathopedagogical (Fedorets, 2018) and propedeutic approaches. Within the framework of this model, a person is viewed simultaneously as semiotic-symbolic system as well as a complex image, which integratively form the corresponding field of senses. At the same time, we believe that the sense-forming potential of a complex human image is determining and primary. We know this from life experience, self-reflection – bight images of familiar people "live" in the consciousness of every person.

In order to increase the efficiency of health preservation in conditions of an educational process, primarily, in diagnostic and preventative aspects, we actualize the issue of using human images. It is through actualization of a human image that the cognitive nature of human Umwelt is disclosed. The define Umwelt as a multi-dimensional structure. One of the dimensions of Umwelt is presented by a system of human images, which disclose human nature in its various aspects in a complex, emotionally full, informationally exhaustive and, what's most important, quick way. Observation over professionals indicate that in addition to the ability to use logic and cognitive schemes they are also able to identify and understand a certain problem "in a flash of a lightning", demonstrating the correct result almost right away. In our opinion, this effect is achieved due to a formed ability to perceive and understand human images as an idea of "Plato's eidos" as well as a complex Gestalt (in the sense of a fragment of reality). Let us particularize that the concept of "eidos" (Ancient Greek ειδοζ – view, image), which was understood as "visible", as a primary image of a person, was primarily formed in the Elin medical tradition. That means that a person in the professional intellectual tradition of Elin medicine was perceived as a system of images or eidoses – normative ad pathological. Such traditional concepts as "Norma" and "Patos" came to us from Ancient Greece. They respectively reflect the idealized human images.

Taking into consideration the professional health-preserving significance and sense-forming potential of human images, which we view as part of a person's Umwelt, we actualize the need of their systemic application in post-graduate education in the course of post-graduate training of a Physical Education teacher. Projected onto the semantic reality, the images form an "unparalleled" and unique "Umwelt of senses". Thus, we determine (as it was stated above) the presence of an image dimension in human Umwelt. This dimension is formed by a system of images, more particularly, by a reality that consists of images. First and foremost, the images reflect the phenomenology of a complexity of human existence and psychic. That is why we view images as a part of the cognitive sphere as well as of value, emotional and existential spheres. To some extent, they are present in human consciousness and Umwelt. That is why, the work with anthropomorphic images, created within the framework of virtual reality, are used in the educational process.

Let us study this on the example of forming practically oriented health-preserving knowledge, cognitive schemes, thinking, attitudes, intentions in a Physical Education teacher. The formation of the stated "competence toolkit" is based on the knowledge about the prevention of development of typical locomotor disorders. In this example, we view the disorders, which may occur due to "excessive" and non-physiological (in the sense of being unnatural) stretching of ligaments and, to a lesser extent, of tendons. The risk of occurrence of such ligament stretching is primarily linked with professional institutions and "fashion" (namely, doing yoga) that are focused on the development of excessive flexibility without proper consideration of morpho-functional and biomechanical basis of joints' functioning, of individual peculiarities of a body as well as of the appropriateness and necessity of this activity.

Thus, taking into consideration the fact that VR/AR technologies are rapidly developing, as well as taking into consideration the epidemiological situation, we were given the task to prepare a report on the possibility of development of VR/AR applications online. Let us start with a simpler system, which is available to the teachers as well as pupils (of elementary, secondary and specialized secondary schools). In the future, we are planning to conduct training sessions using more complex VR/AR technologies. So, les us start.

In this paper, to develop the "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching" we used (CoSpaces Edu, 2021b) by Delightex (Delightex, 2021) – a technological start-up, Munich, Germany, which was founded in 2012 by Yevhen Beliayev, the co-founder of JetBrains. CoSpaces Edu have free plans, a free plan may have some limitation of user options (a set of objects and tools, physical properties of an object, the extended language of scripts, etc.). CoSpaces Edu have also created libraries of readymade VR/AR applications to help the user, teacher, pupil.

It has a wide range of options to be used in education, some of them are (Delightex, 2021; CoSpaces Edu, 2021b): construction of 3D objects with the help of the given toolkit, the creation of interaction elements with the help of either block coding or an extended language of scripts, study of objects in virtual and supplemented realities, use during classes, organization of cooperation between pupils and for viewing together in the real-time mode.

The "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching" software application is formed of five separate components, which contain the following 5 models (CoSpaces Edu, 2021a): Model 1 – "Virtual Normative Model of a Joint"; Model 2 – "Anthropic-Spatial Model of Risks for a Joint"; Model 3 – "Virtual Model of the Pathological Mobility of a Joint"; Model 4 – "Virtual Model of a Joint Space Narrowing", Model 5 – "Anthropic-Spatial Model of Risk Distribution for the Ligament System of Joints".

Using the "Virtual Normative Model of a Joint" (Model 1) (figure 9) (CoSpaces Edu, 2021a), we present a joint as a biomechanical system, in which the spatial dimension is important. In this system, the main structural factor, which puts the boned forming joint together, is the ligaments (or a ligament system, to be more exact). The model focuses the attention on ligaments and on the joint space, which in the normal condition is relatively insufficient in size thus ensuring the optimal contact of bones with one another.

"Virtual Normative Model of a Joint" in "combination" with an image of a person transform into the "Anthropic-Spatial Model of Risks for a Joint" (Model 2) (figure 10) (CoSpaces Edu, 2021a). In

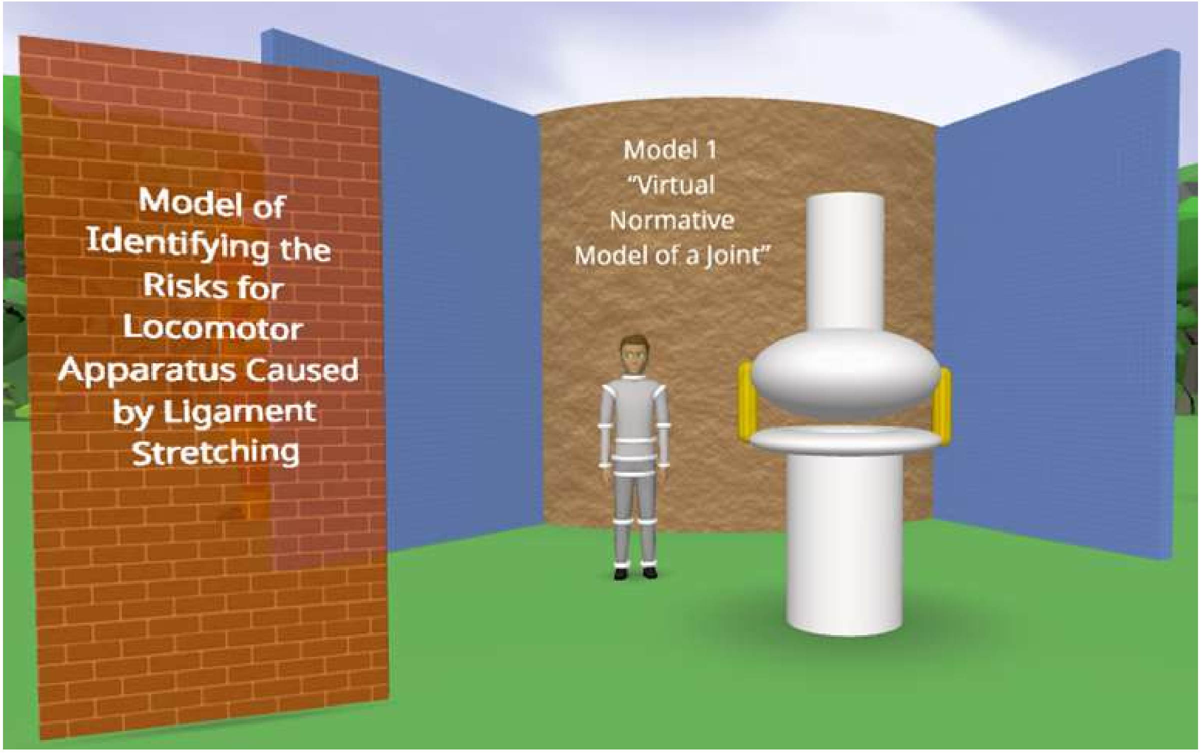


Figure 9: "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching": Model 1 – "Virtual Normative Model of a Joint" (CoSpaces Edu, 2021a).

this model, the image of a person is demonstrated, in which the joints are represented not as anatomic structures (joints), but as relevant and professionally significant "professional" spatial zones that are "put over" the anthropomorphic image of a person (figure 10). Thus, by integrating the human image and specialized knowledge about the joints, we transform the stated knowledge into technological values, intentions, attitudes as well as develop their spatial and motion sense. The corresponding sum of human joints is represented as a spatially organized system of risks. At the same time, the stated system of risks is the sum of technological values that form the basis for organizing motion activity.

Like any other professional a teacher in his professional activity relies on technological values. Quite often, they exist not in the actual, but rather in a "contextual-conceptual" format. Such a contextual format of technological values, as well as of the related intentions and attitudes, does not always make it possible to apply them directly and formally in the educational practices and health preservation techniques. That is why, the methodological idea is to actualize certain knowledge by shifting it from the contextual to the actual form. This is done through representation of this knowledge using the complex

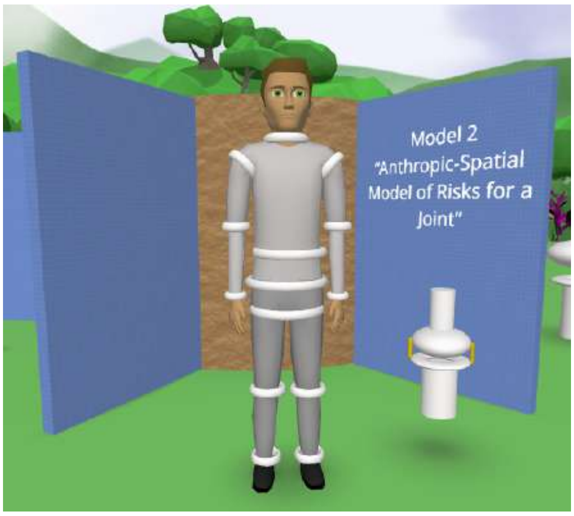


Figure 10: "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching": Model 2 – "Anthropic-Spatial Model of Risks for a Joint" (CoSpaces Edu, 2021a).

image of a person. We call this methodological technique the *"anthropological-graphic technological and value oriented transformation of specialized knowledge"*. With time, the stated technique may be presented as a specific "pedagogical-epistemological technique" aim at increasing the efficiency of forming competences related to the phenomenon of a person. In this particular methodological system, this methodological technique, when specialized knowledge gains an "anthropic image", is first of all aimed at forming the health-preserving intentionality (vector) of an educator, at the development of corresponding visions and technological values. One of the central technological values in this case is a healthy joint in which the ligament system is "preserved" and not overstretched. The stated intentions and values, which determine professional strategies and peculiarities of application of health preserving technologies in the course of organizing motion activity, may compete with the currently fashionable idea of the more flexible the child is, the healthier and fit he or she is.

In order to effectively include the specialized knowledge about the nature of joints in the normal and pathological state into the structure of the cognitive component of the health-preserving competence, we use a comparative approach, which has a significant methodological and graphic potential. That is why, in order to compare with the norm, which is presented in (figure 9), we demonstrate the "Virtual Model of the Pathological Mobility of a Joint" (Model 3) (figure 11) (CoSpaces Edu, 2021a). In this case, the bones of a joint are at a considerable distance from one another, which is a precondition for development of pathologies and state preceding it. The model demonstrated a joint in a pathological condition with stretched and thinned (graphically depicted) ligaments can be formed very "simply", by an inappropriate, excessive and most often determined stretching of ligaments and tendons in the course of workout sessions. While analyzing this model we indicate that in conditions of significantly widened joint gap and of stretched ligaments, the normative biomechanics undergoes pathological changes. First of all, this is manifested in motor disorders, while doing the ballistic components of movements, under static load and in motor actions with objects. The reason for this is that in order to effectively perform movements that have a ballistic component, a relatively hard fixation in the joints is required. In addition, the increased mobility of the joints and the absence of sufficient fixation of joint bones is the artificially created "anatomic and physiological precondition" for development of such a pathology of joints as deforming osteoarthritis and other disorders at a relatively young age.

We also demonstrate another extreme variant, which is opposite to Model 3 – the "Virtual Model of a Joint Space Narrowing" (Model 4) (figure 12) (CoSpaces Edu, 2021a). In this model, the joint space is narrowed. Under typical (normative) human development this variant does not occur. It can develop, strange as it may seem, by stretching the ligaments (figure 11), as one of non-physiological positions of a joint characterized by the absence of the physiologically acceptable and optimal fixation of joint bones.

The next important knowledge aspect of the studied above models oriented at health-preservation is the demonstration (with the help of these models) of ways of optimizing motion strategies on the basis of Anokhin (Anokhin, 1968) studies about functional systems. One of the basic practically oriented conclusions of the study about functional systems is that the locomotor apparatus adapts and "tunes" to different motion activities and workout modes inertially. This determined the strategies for forming the recreational physical training systems not arbitrarily, but rather taking into consideration of inertiality of the locomotor apparatus. Different motion activities functionally determine a different size of a joint space as well as different stretching of ligaments and tendons. Metaphorically speaking, this looks like tuning the strings of a violin for different tunes. That is why, if the inertiality factor is not taken into consideration, other competing strategies may occur. The example may be playing the violin and lifting heavy objects. Thus, a teacher needs to shape motion strategies with the consideration of the inertiality factor, which presupposes readjustment of the body from one motion mode and activity to another.

In the "Anthropic-Spatial Model of Risk Distribution for the Ligament System of Joints" (Model 5) (figure 13) (CoSpaces Edu, 2021a) two images of a person are presented, which visualize and broaden the understanding of risk zones for the locomotor apparatus. In this case the risk zones actualize the significance of not only true joints, as is the case in Model 2 (figure 10). Presenting the risks in an anthropomorphic, spatial and graphic way discloses the value and significance of the ligament system in relation to locomotor apparatus.

The "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching" is first of all conceptual, it's application allows to disclose the essence of many normative and pathological phenomena. The clarity, visual presentation and meaning-forming potential make this model valuable. In conditions of limited time of advanced training courses it allows to relatively quickly disclose the essence of many practical problems and situations that a Physical Education teacher works with.

This model is used in correlation with the idea of self-perception (Foucault, 1988; Jaeger, 1986) and were realized through "taking care of themselves" (Foucault, 1988), which is aimed at making a teacher

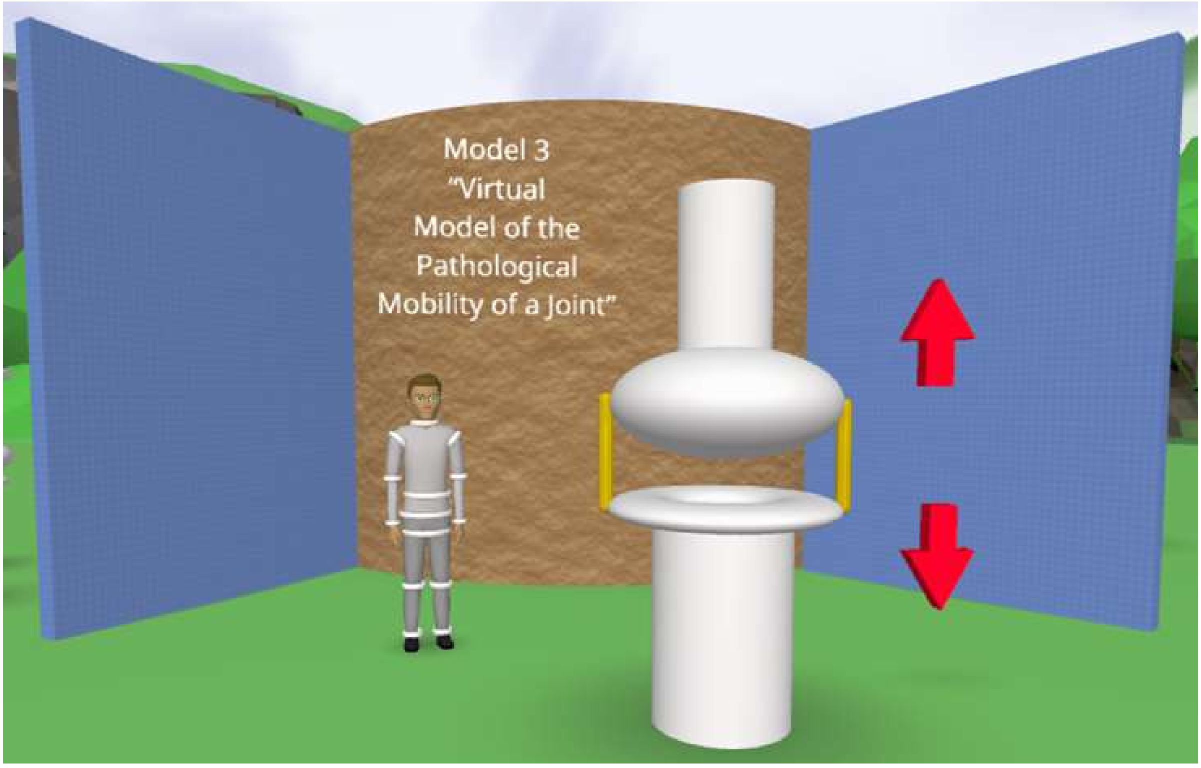


Figure 11: "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching": Model 3 – "Virtual Model of the Pathological Mobility of a Joint" (CoSpaces Edu, 2021a).

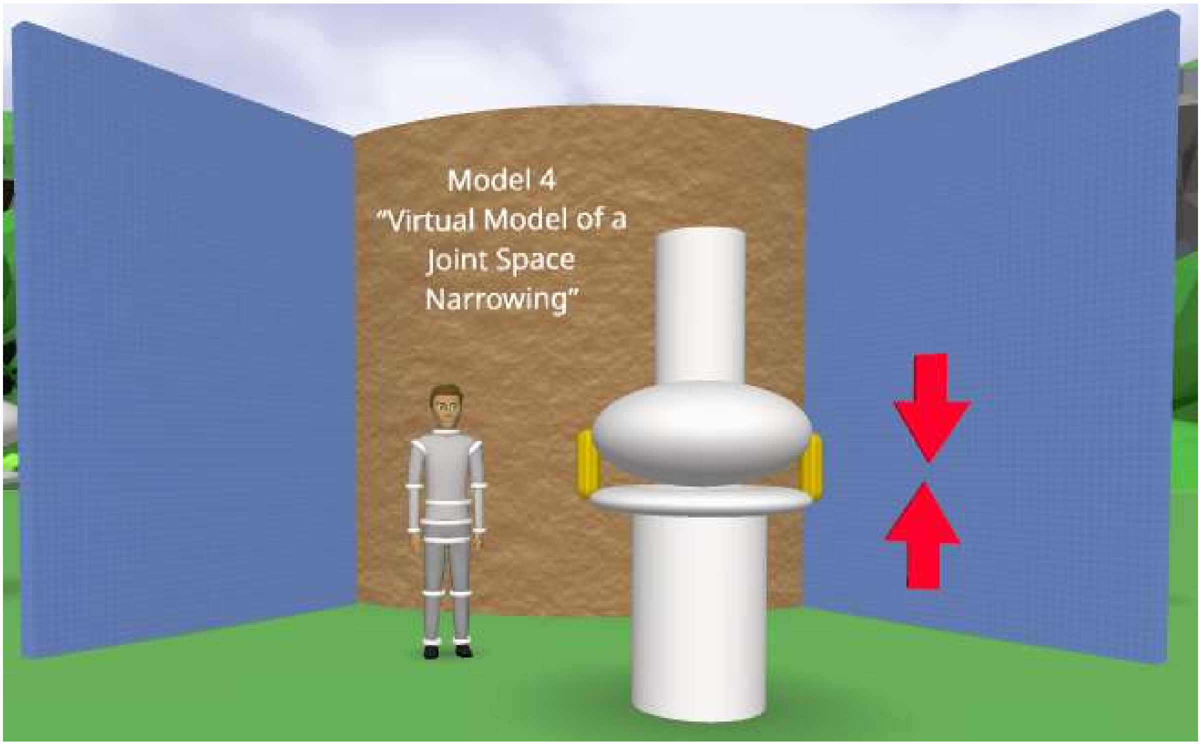


Figure 12: "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching": Model 4 – "Virtual Model of a Joint Space Narrowing" (CoSpaces Edu, 2021a).

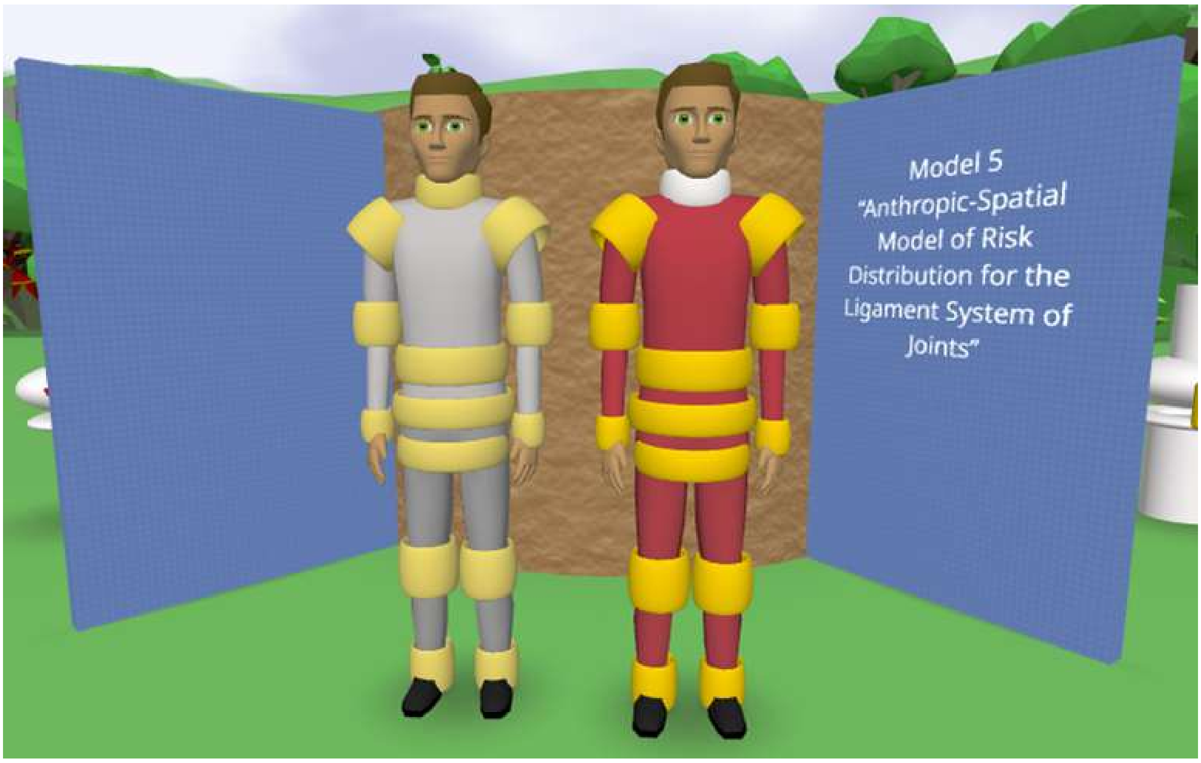


Figure 13: "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching": Model 5 – "Anthropic-Spatial Model of Risk Distribution for the Ligament System of Joints" (CoSpaces Edu, 2021a).

comprehend the peculiarities of biomechanics of certain motion activities through their own motion experience. In order to do this, the bio-mechanic, and, in some cases, also the possible pathological processes and risks of motor activities, are disclosed o through a virtual model and illustrations and a teacher is offered a chance to self-test their influence.

To disclose the stated problematics of preserving the health of a locomotor apparatus, tasks in the form of questions are used:

1. Among the physical exercise known to you, find those which have a clear aspect of non-physiological joint functioning.
2. Analyze the biomechanical peculiarities of the non-physiological physical exercises using the virtual model.
3. Present you pedagogical experience of using the stated exercises.

In most cases, the issue is discussed at the class after Physical Education teachers have worked with it on their own.

In order to determine the efficiency of the teaching in accordance with the "Methodology of development of the health-preserving competence of a Physical Education teacher based on the knowledge of the nature of the locomotor apparatus in the normal and pathological state" we used a system of problems and questions. Accordingly, within the framework of the analysis of the influence of the above mentioned methodology we also assess the efficiency of the "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching", which is a part of the stated methodology.

Experimental study. We studied the efficiency of the application the "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching" as a component of the "Methodology of development of the health-preserving competence of a Physical Education teacher based on the knowledge of the nature of the locomotor apparatus in the normal and pathological state". The research was conducted in 2019 in Public higher educational establishment "Vinnytsia academy of continuing education".

Based on the results of studying these characteristics in a trial study (figure 8, figure 7), in which 36 Physical Education teachers took part, we determine the size of the sample. In 2019 it was planned to teach the "Preserving the Health of the Locomotor Apparatus" course to 62 Physical Education teachers.

The size of the sample n is determined with the help of Student's t-test by formula (1). $N = 62$ is the size of general population.

The value o Student'st-test for the probability of $0,95$ (95%) $t \approx 2$ (Student, 1908). We calculate the size of the sampling using formula (1). $n \approx 48$.

In the course of preparation to conducting a research on the use of the developed "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching" software app, taking into consideration the theoretical knowledge on the given topic that the Physical Education teachers were supposed to study, we have outlined questions the risks for locomotor apparatus caused by ligament stretching, that have to be mastered. For example, "On stretching the ligamentous apparatus" etc (table 1).

The data received before and after the implementation of the methodology with the use of the "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching" software app gave the results shown in table 1 (figure 14).

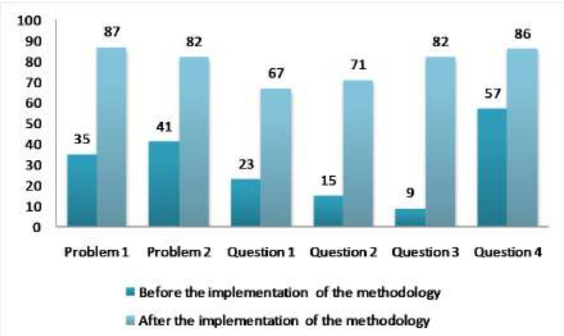


Figure 14: Visualization of data received before and after the implementation of the methodology with the use of the "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching" software app.

As can be seen from table 1 and figure 14, the results of answers to problems and questions are increased significantly after the experiment than before of the application the "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching" as a component of the "Methodology of development of the health-preserving competence of a Physical Education teacher based on the knowledge of the nature of the locomotor apparatus in the normal and pathological state". The most effective application of this methodology was for the problem "1. On stretching the ligamentous apparatus" (+52%) and the questions "2. About the risks of deforming osteoarthritis development" (+56%), "3. About mechanical energy accumulation in ligamentous and tendons" (+73%). Because the implementation on the basis of the Umwelt concept, the anthropological paradigm and virtual models of the Locomotor apparatus, provides an opportunity to implement indirect and contextual influences, cognitive, interactive, anthropomorphic, image-based and personalized nature as well as others characteristics of Umwelt oriented technologies of AR/VR.

4 CONCLUSION

The use of AR/VR technologies is an effective innovative technologies of development of a health-preserving competence of a Physical Education teacher under conditions of post-graduate education. Improving the methodology of use of the AR/VR technologies for the development of health-preserving competence of a Physical Education teacher under conditions of post-graduate education was carried out on the basis of the anthropological paradigm and the concept of Umwelt. Umwelt represents a "perceptive-acting" world of a person. A person's Umwelt has a sense-forming potential. Such features as correspondence to nature, indirect and contextual influences, cognitive, metaphoric, diverse, interactive, anthropomorphic, image-based and personalized nature as well as other characteristics, which take into consideration the anthropological and personalized peculiarities should be characteristic of Umwelt oriented technologies of AR/VR.

The relevant forms of AR/VR representation with the purpose of improving the health-preserving competence of a Physical Education teacher include the combination of the content with real time or recorded comments, graphic images, graphic analysis; realistic 3D simulations, assessment of the training session, etc. the important vectors of using augmented reality with this purpose is the development of study videos, techno sport, simulation and watching sports competitions and workout sessions, educational marketing etc. As for a Physical Education teacher the application of AR/VR in the educational process facilitates professionalization, technologization, axiologization and humanization of his/her professional activity, including its health-preserving component, technologies into the educational process in order to conduct Physical Education lessons, workout sessions, sports competitions, rehabilitation activities etc.

Based on the analysis of the currently available areas of use of the AR/VR technologies, as well as through its methodological understanding, we point to the significant innovative, educational potential of this digital technology. From a methodological point of view, the use of the augmented reality correlates with the application of the concept of Umwelt, contributes to the formation of meanings, semantic con-

Table 1: The data received before and after the implementation of the methodology with the use of the "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching" software app.

Tasks	Before	After	Deviation (+/-)
Problems			
1. On stretching the ligamentous apparatus	35%	87%	+52%
2. On the significance of flexibility developing exercises	41%	82%	+41%
Questions			
1. About the stretching of the spine	23%	67%	+44%
2. About the risks of deforming osteoarthritis development	15%	71%	+56%
3. About mechanical energy accumulation in ligamentous and tendons	9%	82%	+73%
4. About the structural organization of a joint	57%	86%	+29%

texts, values, patterns of action, images, semantic images, motor images, and images of health. This determines possibilities for extended and innovative use of the augmented reality for the development of a health-preserving competence of a Physical Education teacher in particular.

A survey was conducted to reveal the understanding of a value potential of the augmented reality. The attitude of Physical Education teachers to the use of the augmented reality in an educational process to preserve their students' health and develop their motion skills, intellect and creativity was determined. Analysis of the results of the questionnaire was performed, the aim of which was to determine the attitude of Physical Education teachers to the use of the augmented reality in an educational process for preserving their students' health and development of their motion skills, intellect and creativity. It is determined that most teachers (57%) treat positively this problem, 18% – negatively and 25% were not sure about this question. We can explain such a division of answers by not sufficient awareness of Physical Education teachers of an educational potential of the augmented reality.

Umwelt of a person is viewed as a multidimensional phenomenon. A system of images of a person is presented as a relevant dimension of a person's Umwelt, as they disclose the anthropic essence of a person in a value oriented, informationally exhaustive and emotionally filled way. The study uses the representation of special knowledge using a complete image of a person. The use of anthropomorphic images created with the help of the AR/VR technologies is actualized.

In order to improve the health-preserving competence of a Physical Education teacher in the course of post-graduate training the "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching" software application has been developed. The developed virtual model "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching" in the system of tools "Methodology of development of the health-preserving competence of a Physical Education teacher based on the knowledge of the nature of the locomotor apparatus in the normal and pathological state" was used for solving and analyzing pedagogical problems and questions, analysis of anthropological phenomena. As a result of the conducted experiment the positive dynamics of results of training of the physical education teachers on the basis of the given methodology with use of virtual model is defined.

The "Virtual Model of Identifying the Risks for Locomotor Apparatus Caused by Ligament Stretching" consists of 5 models: Virtual Normative Model of a Joint, Anthropic-Spatial Model of Risks for a Joint, Virtual Model of the Pathological Mobility of a Joint, Virtual Model of a Joint Space Narrowing, Anthropic-Spatial Model of Risk Distribution for the Ligament System of Joints. The stated model discloses the phenomenology of a joint both in the normal and pathological state in a representative and practically oriented way. Thanks to this model, a teacher forms the understanding of risks for the locomotor apparatus as well as of the anthropic-spatial system. On the basis of the innovative and practically-oriented disclosure of special knowledge about the locomotor apparatus, the virtual model facilitates the development of health oriented mental tools of an educator, i.e. of knowledge, thinking, visions, orientation, technological values, which, together with other components, form the health-preserving competence of a teacher.

The ways of effective introduction of AR/VR technologies in health-preserving activity of a Physical Education teacher are more active bringing specialists to the development of software additions of the AR/VR technologies as well as its introduction into an educational process. Important in this aspect is the use of the anthropology oriented approaches that assist humanization of an educational process and technological adaptation of the AR/VR technologies to the nature of a person.

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