



Developing Gamified Instructional Materials in Genetics for Grade 12 STEM

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Abstract:

As technology advances, the demand for innovative instructional materials also increases. As a result, the Department of Education urges teachers to develop instructional materials. This study was conducted at Bulusan National High School, Bulusan, Sorsogon, Philippines SY 2018-2019 which was aimed to develop gamified instructional materials in genetics that would aid in teaching and learning process of grade 12 STEM students. The developed gamified materials were collectively called the GIM in Genetics which is comprised of two parts; namely, Student's Portfolio and Gamified Lesson Plans. The GIM was anchored on the Teacher's Guide provided by DepEd. Further, it utilized different game elements, to wit: game mechanics, badges, power cards, scoring system, levels, and leaderboards to deliver innovative teaching strategy and quality education. This paper suggests the development of various innovative teaching strategies and instructional materials as well as its utilization across different fields and subject areas.

Keywords: development, gamification, gamified instructional material, genetics, lesson plan, portfolio, STEM.

I. INTRODUCTION

The 21st century learners are known to be born where technology is an integral part of human life. For this reason, technology becomes a necessity and integrating it with their everyday school activity is vital. As technology improves, different types of games are also being developed to elicit interest and motivation among students. Moreover, these give rise to different game components and elements. As a result, technology is being fused to learning environments which use game elements, a process called gamification. Gamification per se is the use of game mechanics in a non-gaming context and is positive and intrinsically motivating gameful experiences [1][2]. Both technology and games when used in teaching have positive effects on psychological and behavioral aspects and can be more enjoyable [2][3]. For instance, digital based-games as one of its kinds, can decrease cognitive load, improve learning achievements and increase student's motivation [4]. However, with the presence of gamification's positive effects, competent gamification of learning environment necessitates suitable technology and appropriate strategy. Further, empirical researches for a specific game element incorporated to education are lacking which makes meta-analysis difficult [5]. One of the goals of this study was to develop an instructional material to aid in teaching strategies, as well as to address the scarcity of researches on gamification. This study aimed to develop Gamified Instructional Materials (GIM) in science, specifically in genetics for grade 12 with the aid of modern devices and technologies. Instructional material is an integral part of teaching process. It is important to help teachers in improving students' knowledge, abilities, and skills in the form of textbooks, modules, manuals, worksheets, multimedia materials, etc. [6]. The GIM intended to serve as tool geared towards the delivery of quality and motivating education. DepEd order number 39 series of 2016 entitled, "*Adoption of the Basic Education Research Agenda*", stipulates a mission for students to learn in a child-friendly, gender-sensitive, safe and motivating environment [7]. To this end, the DepEd urges educators to conduct evidenced-based studies under their

research agenda. The development of GIM is in accord with D.O. No. 39, s. 2016 under research agenda Theme 1: Teaching and Learning, where educators are encouraged to study different teaching strategies, develop lesson plan, and create instructional materials [7]. In 2015-2016, the Global Competitiveness Report of the World Economic Forum showed that Philippines ranked 67th out of 140 countries in terms of quality of math and science education; 79th of 138 in 2016-2017, and 76th of 137 in 2017-2018 [8]. One of the identified reasons for this slow growth was the learning process [9]. In order to address this problem and increase the country's performance in science, new strategies and approaches in teaching should be introduced to students. Among the subjects in the biological sciences, Bulusan National High School science teachers' common observation is that students are having a hard time studying genetics. This claim was supported by Lewis and Kattmann (2004) and Duncan and Reiser (2007), who studied why genetics is one of the challenging subjects in biology [10][11]. Economy is dependent on education [12]. As society changes continuously, education should also change. By exploring new and better ways to educate students, teachers may positively affect the future economy and society. Moreover, to improve science education, teachers should collaborate with one another in improving students' scientific knowledge and skills [13]. Further, educators need to design processes that involve students' mental, physical and emotional processes. To address these issues and concerns in science education, this study developed a new way to deliver quality genetics education by innovating instructional materials. Overtime, students may get used to the utilization of technologies and games in learning which may lead to decrease in motivation, satisfaction and empowerment. In turn, this may result to complacency. As a consequence, lower performance level may transpire [14]. To prevent and avoid this kind of situation, there is a necessity for educators to continue developing innovative strategies and teaching materials for student's learning. This study was conducted at Bulusan National High School, Bulusan, Sorsogon involving one intact grade 12 Science, Technology, Engineering and Mathematics (STEM)

class and experts in the field of Biology education. The purpose of this study was to follow D.O. No. 39, s. 2016, and develop an innovative teaching material using gamification which may aid educators in delivering quality and motivational learning. This may also add to research references where gamification in education was applied in secondary level, as most of the study related to gamification in education were conducted in Higher Education [15].

II. METHODOLOGY

The development of gamified instructional material took a period of one month from the third week of November to the last week of December 2018. During this time frame, the researchers gathered ideas and information from different students, literatures, and field experts. As a result, the Gamified Instructional Materials (GIM) in Genetics was developed.

III. RESULTS

The researchers made use of gamification employing modern technologies and computer programs. However, not all students in Bulusan National High School had an access to computers, thereby hindering them from utilizing computer-based games. In this study, modern technologies were used for the development of GIM (see figure 1) as a tangible instructional material which was utilized by teachers and students despite the limitations of computer accessibility.

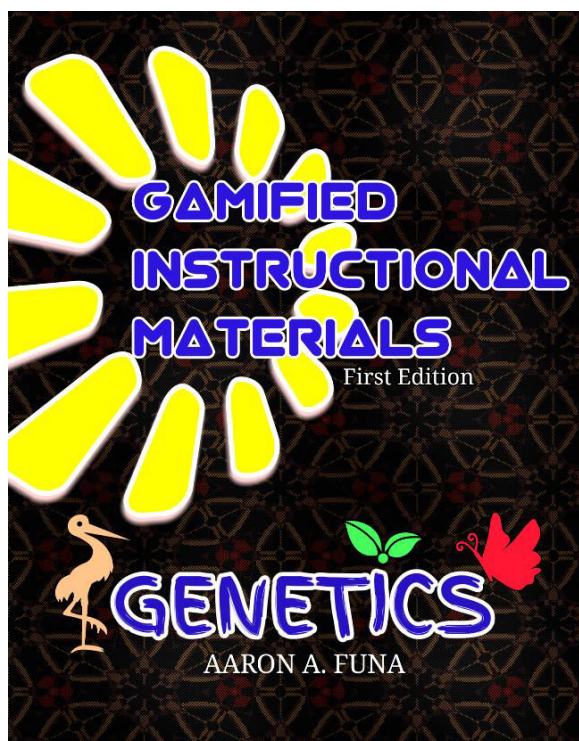


Figure.1. Gamified Instructional Materials in Genetics

The GIM is divided into two parts: Student's Portfolio and Gamified Lesson Plans. It makes use of images and illustrations derived from Logopit® plus android application, DepEd's Teacher's Guide (TG), and internet sources [16][17].

Student's Portfolio

The Student's portfolio is the first part of the GIM. This is given to each student in order to join the game. Further, it keeps their identity, scores, and other necessary data intact and organized. It consists of cover, game mechanics, badge types,

power cards, scoring guides, character's level, character's profile, badges earned, points earned, journal logs, and leaderboards. Using this allows teachers to track the status of their students. Additionally, it makes students' learning experience fun, motivating, and gamified.

Cover. It shows the title, "The Book of Genetics", the player's name, and the different badges as its background. The colors and shapes of the cover were made purposely to make the students enticed and motivated in accomplishing its contents. The use of face-like shapes and warm colors may induce positive emotions and facilitate comprehension. It may also reduce the difficulty of tasks [18].

Game Mechanics. Based on Deterding et al. (2011), the use of game mechanics in a non-gaming context is termed gamification [1]. In this case, the study utilized game mechanics to make teaching gamified. It contains a set of rules and regulations of the game. Moreover, it explains systematically the different aspects a player may do in order to win the game. In addition, it serves as a tangible guide for the players to engender a smooth play which they can scan from time to time. By reading the game mechanics, students may be able to visualize and formulate their future strategies.

Badge Types. This part holds the different badges which can be obtained by engaging in the game. Badges are comprised of visual and textual cues, rewards, and goals to fulfill [19]. Each badge has corresponding points and descriptions. In order to get one, the player must successfully carry out the task described in a certain badge. Points earned from getting a badge will be computed and added to the total Life Points (LP). The use of badges has already been demonstrated to be positively motivating, and effectively increasing passing rates and participation of students [20]. Whereas, the colors and shapes used may help induce students' motivation and reduce difficulty of tasks [18]. The main purpose of badges in this study is to encourage students in doing and accomplishing tasks. In addition, it also serves as the teacher's bases to determine where a specific student excels most. For instance, when a certain student obtained more badges in recitation, the teacher can easily identify that the student has been actively reciting in the class.

Power Cards. This part exhibits different power cards used in the game. The use of power cards was identified by Iosup and Epema (2014) as one of the core mechanics in gamification [20]. Each of the cards has different names and powers/capabilities as described in the power cards table of GIM. The game master has the full power over the time of their availability and utilization during a certain activity. The use of cards made the activities more fun and exciting, knowing that the players have abilities and powers to be utilized. Moreover, it may help the players in strategizing which in turn develop their critical thinking and decision-making skills to win the game.

Scoring Guides for Journal Logs. It is a rubric that shows the different points a player can get in accomplishing journal logs. It has three categories: 1) word count, 2) content, and 3) hand writing. This guides the players on the contents and how journal logs should be done. Once done, the game master will check it. Points earned from the checked journal entries shall be added to the overall points gained in every lesson.

Character's Level. It displays the different levels that a player can get when they achieve a certain amount of LP. In

addition, each level has a reward. When the player achieves a certain level, he/she may unlock that reward. This may serve as a motivation during or in between lessons. Through this, players do not only look at the game's end result but may look forward and monitor their points at every end of the lessons. The idea of point system and increasing the character's level was based on the identified core mechanics of Iosup and Epema (2014) [20]. Likewise, unlocking the contents when a certain level was reached is under the four core dynamics of their study. These are some of the elements they use to increase students' participation, performance, and satisfaction. Further, this study used those for an equivalent purpose.

Character's Profile. It is the part of student's portfolio where players can play with their creativity and imagination. In this section, players have to create the appearance of their character, its name, age, weaknesses, powers and description/background story. The name of their character serves as their pseudonym. The use of pseudonym may prevent competition among students, rather promote competition within themselves. Further, it makes the lead boards and ranking more mysterious and exciting.

Badges Earned. In this part, players have to put and stick the badges on the boxes provided. Through this, it is easier for the teacher and the students to monitor and calculate the earned badges for every lesson. Additionally, teachers can easily identify where a specific student excels most by identifying the type of badges they have earned.

Points Earned. It is the part where the game master records each point that students have earned from the badges, classroom activities, and assignments, as well as the points that have been deducted from buying power cards. Every after the lesson, the game master has to calculate the points and display it on the box provided. After the whole lesson in genetics, points will be totaled to determine the winner of the game.

Journal Logs. This is the part where students can freely write their feelings, thoughts, and suggestions on the lesson and the game. It empowers students by expressing their own selves. Moreover, it is a venue for teachers to collect each of their student's ideas. Through this, teachers can improve the way they deliver the lessons and the game based on students' responses. This serves as a venue for communication between the teacher and the students. Each journal log accomplished by students will be given points that will be added to their overall life points.

Leaderboards. Its use can increase students' motivation and participation. This part was not included in the student's portfolio; however, this is one of the game elements and strategies used. In this study, this was displayed on one of the corners in the classroom for the whole class to see. This is where rankings and pseudonyms are posted. Through this, players can monitor and compare their performances with other players in the lesson and in the game. Furthermore, this may motivate other students to come up with better strategies and to try even harder to be included in the leaderboards.

Gamified Lesson Plans

The second part of GIM is the compilation of seven gamified lesson plans targeting the seven learning competencies in genetics. It uses the six E's (Engage, Explore, Explain, Elaborate, Evaluate, and Enrichment) fused with game

elements. This may guide educators in the execution of gamification in teaching genetics. Moreover, this may direct teachers to perform a new way of teaching with the purpose of providing students a child-friendly and motivating learning environment. The GLPs focused on Genetics which is one of the major concepts in General Biology 2 under the K-12 curriculum for Senior High School (SHS) Science Technology Engineering and Mathematics (STEM) strand. It is composed of four content standards: 1) Mendel's Laws of Inheritance, 2) Sex Linkage, 3) Central Dogma of Molecular Biology, and 4) Recombinant DNA. In addition, it has seven learning competencies: 1) predict genotypes and phenotypes of parents and offspring using the laws of inheritance, 2) explain sex linkage and recombination, 3) describe modifications to Mendel's classic ratios, 4) illustrate the molecular structure of DNA, RNA and proteins, 5) diagram the steps in DNA replication and protein synthesis, 6) outline the processes involved in genetic engineering, and 7) discuss the applications of recombinant DNA. This study covered all learning competencies under genetics which led to the development of seven GLPs namely: 1) Pedigree Analysis, 2) Sex Linkage and Recombination, 3) Modification to Mendel's Classic Ratios, 4) Molecular Structure of DNA, RNA, and Protein, 5) DNA Replication and Protein Synthesis, 6) Genetic Engineering, and 7) Discuss the Applications of Recombinant DNA. These lesson plans were elaborated in the second part of GIM. Each GLP in genetics was adapted from the Teacher's Guide (TG) provided by the Department of Education. It was modified to suit the teacher's capacity and learner's needs. Further, it utilized symbols made from Logopit® plus android application which hints players that a badge should be awarded if they successfully accomplish the given activity. Moreover, it uses game elements like points, badges, power cards, leader boards and levels. These elements may cause positively helpful effects in increasing students' performances and participation [20].

IV. CONCLUSION

With the availability of modern technologies, teachers may innovate instructional materials utilizing variously existing researches. The development of GIM used the information coming from students, teachers and researchers. The researchers recommend GIM for utilization of students and teachers in learning and teaching processes. This may help them in evaluating the material's overall capacity as well as gamification as teaching strategy. Moreover, the students' portfolio and the method of gamifying the lesson plans is recommended to be utilized in other subject areas. This may lead to developing other innovative instructional materials for quality education.

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