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TRADITIONAL GUIDED LAB ACTIVITIES IN THE PHYSICS LABORATORY OF ENGINEERING INSTITUTIONS IN KATHMANDU DISTRICT OF NEPAL

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ABSTRACT

Laboratory activities play a crucial role in the conceptual understanding of the theoretical aspects of physics. Traditional guided lab activities emphasize a teacher-centric pedagogical approach in which learners are merely passive recipients of the content knowledge as delivered by the teacher. The authors in their professional journey at engineering institutions were also guided by the traditional laboratory approach in the teaching and learning process inside the physics laboratory. During our professional journey at engineering institutions, we felt that students had difficulty demonstrating the science process skills and employing the theoretical aspects in real-world situations. The primary objective of this research was to explore the lab activities inside the physics laboratory at diploma engineering institutions in the Kathmandu district of Nepal. For this purpose, an ethnographic method was employed in which multiple laboratory sessions were observed, and open-ended and unstructured interviews were conducted with the research participants at different locations through in-person and online processes. In addition, social constructivist learning theory was utilized in this research process. The findings lead to the conclusion that traditional guided laboratory activities prevailed inside the physics lab of those institutions under study.

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INTRODUCTION

Physics laboratory validates the theoretical aspects of physical concepts and ideas through experimentation. Laboratory learning pushes students to address their misconceptions about phenomena and move toward better understanding. Laboratory experiences assist students in mastering scientific information and are based on the notion that providing students with opportunities to directly engage with, observe, and manipulate things would aid students in better understanding complex scientific topics (Singer et al., 2006). Appropriate practical work improves students' exposure to, comprehension of, competence in, and enjoyment of science. Students can think and behave scientifically (Musasia et al., 2012). Laboratory learning fosters scientific attitudes and enhances conceptual knowledge and problem-solving abilities.

Traditional guided laboratories are highly structured and cookbook in nature (Wilcox & Lewandoski, 2016) which are typically characterized by using laboratory manuals to cover a preset topic for the completion of data collection and using those data to get the desired results. From the perspective of Habermasian knowledge constitutive interest, the physics practical classes fall in the category of technical interest (Taylor & Campbell- Williams, 1992) driven classes in which the teacher defines the issue to be examined, makes students repeat instructions, or follow the instructions in a lab manual, and then compares the outcomes to a preset outcome known to both students and the teacher (Clark et al., 2015).

Based on several years of teaching experience inside physics laboratories of engineering institutions in Kathmandu, the authors emphasize that teaching and learning inside a physics laboratory has its roots in the traditional guided laboratory approach. The practical classes in institutions where the authors taught for several years were conducted once a week for a specific group of students such as civil engineering, computer engineering, Architecture engineering students, and so forth. The whole class was divided into three to four groups depending on the number of students in that class. The practical classes were 90 minutes in duration. Students were involved in their respective groups as formed by the laboratory assistant.

The laboratory assistant supplied instruments to all the students. Students were seen carrying lab manuals consisting of certain sets of experiments to be covered during the entire semester of study. The lab manual was such that data from the experiment conducted must be filled in, and students must show the data gathered from the instruments, the tables of data gathered, and the findings of the experiments to the teacher. In this sense, physics laboratory learning was aligned with the technical interest-driven laboratory as it employed empirical-analytic treatment to attain predetermined outcomes.

In addition, due to the conventional teaching model in physics laboratories in engineering institutions of Kathmandu (Ghimire, 2023) learners were forced to memorize the knowledge they received which restricted their development of science process skills (Prayitno et al., 2017). The authors during their professional career found that due to the lack of basic process skills in observation, inference, classification, communication, measurement, and prediction (Darmaji et al., 2019) most of the students were not able to repeat the same experiment they did before some time. The consequences were that learners were unable to apply the conceptual understanding of physical concepts in real-world contexts.

Moreover, integrated process skills such as identifying variables, defining operational terms, forming hypotheses, designing and conducting experiments, and drawing conclusions (Dillashaw & Okey, 1980; Shahali & Halim, 2010) were far-fetched goals for the learners to achieve.

METHODOLOGY

Research design

A qualitative method was employed in this research to dig deep inside the traditional guided laboratory approach and an ethnographic design was employed in this study. Through ethnography, the teaching and learning practices were explored as ethnography portrays written representations of the selected aspects of a culture under study (Van Mennon, 1988) which in this context is lab activities inside the physics laboratory. Ethnographic fieldwork is chiefly characterized by participation and observation (Gubrium, 2014) but it has also focused on something else; how people account for their own experiences, about their lives and others. Through participant observation, the main method of ethnography (O'Reilly, 2005), the lab activities were observed, and then through the interviews of participants their comments about groups were recorded.

Description of the research site

In order to conduct the study, two diploma-level engineering institutions affiliated with the Council for Technical Education and Vocational Training (CTEVT) were selected as the research site at which participant observation was conducted. Institution A was a polytechnic institution whereas institution B was a mono-technical school. Institution A was the oldest engineering institution in the Kathmandu district and there were around 300 students in first, second, and third year of study. On the other hand, there were 140 students in institution B in the first, second, and third year of the course of study. The first-year diploma-level engineering classes of the physics laboratory at Institution A and Institution B were targeted for the data collection process. The research site typically focused on the physics laboratories of those institutions. Institution A comprised 16 students in session inside the physics laboratory whereas institution B comprised 12 students in a lab session.

Research participants

A purposeful sampling technique was employed in order to select the research participants. For this, first-year students from computer, electrical and electronics engineering group were selected for the participant observation. The participants from Institution A were P1, P2, P3, P4 while the participants from Institution B were P5, P6, P7, P8 and P9.

Data collection approaches

First, the data was collected by employing participant observation classes inside the physics laboratories. Data was collected through multiple class observations during the entire semester of study. In doing so the laboratory activities while teaching and learning physics through experimentation were emphasized. In addition, data was gathered from multiple rounds of interviews with nine research participants from Institution A and Institution B as in qualitative interviews the responses of participants would be highly prioritized and their views wouldn't be restricted (Bryman, 2012). The interviews were conducted through face-to-face and online modes such as Zoom and Google Meet. The responses were recorded in a self-designed protocol (Creswell, 2012) which was the mobile phone of the interviewer and then kept safe till the data was transferred to the computer drives.

Data analysis strategies

Data analysis is a pivotal step in qualitative research that ensures the outcomes of the research (Flick, 2014). The data collection in this research was based on observation and interviews so qualitative research is concerned with analyzing such aspects of data collection tools. The observational notes and the interview transcripts were analyzed first by coding the data. Data was coded meticulously, and several categories were formed from those coded data. Amalgamating those categories three major themes emerged from the research findings that are discussed below.

FINDINGS AND DISCUSSIONS

Teachers' controlled learning

During the participant observation, the first author noticed that the physics practical activities were designed based on group teaching and learning. Students were found to carry an instructional laboratory manual with them. The concerned teacher and the laboratory assistant at both institutions formed two to three groups depending upon the number of students enrolled in a specific program such as computer engineering course. Some groups contained a minimum of 3 students while others had a maximum of 6 students. Moreover, students in the groups were engaged in utilizing the devices to record the scientific readings.

Responses from the participants also revealed the same scenario:

P3 says that.

> The teacher instructs us to do experiments and I follow what he says and does while conducting the experiment.

P4 mentions a disturbing scenario.

> While experimenting with a traveling microscope we encountered a vernier scale which we didn't experience ever before in our lives. It was new for us. Once the teacher told me about the vernier scale in experiment 1. I didn't understand it properly. Then the teacher asked me to take the readings from the device and scolded me as I was confused. Again, I asked him and this time he also scolded me. He scolded me twice in one session. He should have talked in a good way.

P9 mentions that.

> After entering the lab, they provided with us the apparatus. After that we asked the teacher what to do and how to do it and he came and demonstrated to collect the data by doing himself and we conducted accordingly. We did as per his instructions.

P1 claims that.

> The teacher tells us which experiment to do. After receiving the apparatus, we call the respective teacher and ask him how to conduct the experiment. The teacher explains to us. He tells us the steps of the experiments. According to the teacher's instructions, we find the values of the physical quantities, fill in the data, and submit it to the teacher.

P2 asserts that.

> After entering the lab, the teacher tells us which experiment to perform. He then teaches us how to experiment and tells us to do it in the same way.

P6 claims that.

> The teacher explains the experiments for examples melting point of wax and travelling microscope. The teacher shows the scale attached to the device and instructs us how to do it in a proper manner.

P7 claims that.

> There are some topics of experiments. First, we need to take the apparatus of the concerned experiment and then the teachers come to our group and teach us stating that this experiment should be performed in a specific way.

P5 claims that.

> At first the teacher describes the experiment and the instrument and then he tells how to conduct the experiments, how to collect the data from the instruments and then we start doing the experiment as per the teacher's instructions.

P8 claims.

> Experiments are performed in a group. The teacher starts the experiments by showing us how to deal with the equipment and collect the necessary data using the device. We perform following the teacher's guidelines.

All participants shared similar views regarding teaching and learning physics through experimentation. However, from the researchers' lens, we assert that students were not fully autonomous in collecting the data because students conducted experiments step-by-step in accordance with the teacher's provided instruction manual (Chung et al., 2010) which didn't allow students to further explore the experiments. It seemed that the teacher was assisting the students in the data collection from the instruments, but the scenario was different. The teachers emphasized providing prescriptive knowledge and skills thus focusing on the predetermined outcomes of the experiments rather than allowing students to discover alternate solutions (Pyatt & Sims, 2007). Moreover, the lab activities were aligned with the research conducted by Yesilyart (2022) who argues that science teaching is knowledge transmission with the teacher acting both as a source and transmitter of knowledge having strict control over the learning process. In doing so the teacher is involved in disseminating the directed and structured inquiry in the learning process. On the other hand, learners were the passive recipients of the content knowledge (Emalia, 2017).

Laboratory Manual

The observation classes inside the physics laboratories of both engineering institutions revealed that the culture of learning experimental physics was emphasized by gathering data from the specific device(s) and filling it in the laboratory manual. The observer noticed that students submitted their previous work to the teacher for the necessary corrections that they had written in the manual book. On the other hand, teachers at both institutions emphasized laboratory manuals as a cardinal instructional approach while dealing with those experiments. The laboratory manual served as a key learning material in physics laboratories.

Participants responses regarding the laboratory manual were as follows.

P5 mentioned that.

> After completing the experiment, we fill the data in the lab notebook and perform calculations and show it to the teacher. The teacher asked us to submit the report early.

P3 reported that.

> We collect the data on a rough exercise book thus finding the values of length, internal, and external diameters, etc then transfer it to the practical guide. After one week we ask the teacher to check it.
>
> She further added that, once the teacher in angry mood told one of my friends that he won't check the lab work as it was not submitted on time.

P4 claimed that.

> The department has developed a lab manual for us in which there are experiments to be performed. We in a group experiment on a day and then after a week we submit it to the teacher. The teacher showed rude behavior to me by ignoring my work as I had submitted it after the deadline.

P9 said that,

> The teacher had asked us to buy a lab manual. In the manual there are 10 experiments, and we must fill it with the data we gather in the lab and then show it to the teacher.

P1 claimed.

> The college asked us to purchase a lab notebook and we all did the same. Sometimes we fill the data on the same day of the experiment and sometimes we fill the data in the lab exercise book at home.

P6 said that.

> I collect the data on the day when I do the experiment and transfer it to the lab manual and then submit it for the correction.

P2 mentioned that.

> We put the data into the lab manual and ask the teacher to check the correctness of the result. The teacher checks and provides us necessary suggestions.

P7 mentioned that.

> We generally take data on a rough exercise book when we experiment with and then we transfer the data into the lab notebook. We show it to the teacher. The teacher makes necessary corrections to it.

P8 claimed.

> A lab manual is a notebook for us to write the data and perform calculations. I first write the data on another exercise book and after completing the experiment I put the data again in the manual. I then submit it to the teacher after a week.

Participants' responses also revealed that the lab manual was being utilized for the purpose of teaching and learning experimental physics inside the physics laboratories of both engineering institutions. Some researchers claim that lab manual fosters a traditional instructional approach in the teaching and learning process. They pointed out several drawbacks of the lab manual.

According to Fadaie (2021), the cookbook instructional approach in the laboratory dictates to learners what, how, and when to think. Consequently, the learning benefits of lab activities are largely lost. The researcher further claims that recipe-like exercises frequently cut off the opportunity to stimulate students' thinking. In addition, such labs include extremely thorough instructions that allow students to follow a recipe without having to think about it. Students cannot perceive what they are attempting to convey in this type of lab work.

Likewise, Ural (2016) asserts that the outcome of this method is predetermined because students follow the directions in the lab manual step by step. Moreover, students only consider following the lab manual and conducting the experiments within the constraints of time and resources. Also, Clark et al. (2015) claim that such a type of laboratory has been the dominant lab instructional approach for decades. In this approach, instructors designate the topic to be investigated, offer the context for investigation, and then ask the learners to respect the guidelines or follow them from a manual. Instructors and students then compare the results with predetermined outcomes. A notable fact is that very little emphasis is placed on critical thinking and conceptual shift. According to Brownell et al. (2012) typically structured labs, which are common in high school and college settings, provide students with exhaustive directions and engage them at a low intellectual level by formulating a recipe-like activity.

Many students are also unaware of the significance of the results of the experiments. The authors also assert that the cookbook lab adheres to instructions that ignore the conceptual and procedural understanding of the study.

The authors of this research also agree with the claims made by Fadeai (2021), Ural (2016), Clark et al.(2015) and Brownell et al.(2012) as we think that the expository laboratory creates a hindrance to grasping basic and integrated science process skills among the learners. We, in our several years of teaching in engineering institutions, have seriously realized that students were under immense pressure to follow the prescribed protocols as set by the concerned stakeholders and the learning was least concerned with implementing these types of science process skills. The consequences were that students ended up reciting facts and receiving the predetermined outcomes of the experiment rather than questioning, designing, conducting, analyzing, and finally examining the outcomes.

Lack of active learning approaches

During the observation classes, the researcher noticed that there was a lack of active learning processes such as inquiry-based learning, project-based learning, problem-based learning and discovery-based learning (Pokherel, 2022).

Based on the conversations with the participants it was revealed that no such learning approach was employed inside the experimental classes and the laboratory activities were strictly based on the fixed set of experiments to be conducted in accordance with the curriculum. In this sense, laboratory activities were guided by curriculum teaching (Popham, 2002) rather than active learning process.

In the active learning process, learning is emphasized over the teaching process and there is a paradigm shift from the teacher-centric to learner-centric approach to instruction in which learners are provided with considerable autonomy and control over the direction of the learning activities (Anthony, 1996).

However, findings indicated that the teaching and learning activities inside the physics laboratory at both institutions were not coherent with active learning approaches.

CONCLUSION

This study reported the major aspect of the laboratory activities inside the physics laboratory of engineering institutions. The traditional guided laboratory approach was being promoted in teaching and learning physics experiments. The traditional guided laboratory activities were chiefly characterized by the implementation of the physics lab manual in the entire teaching and learning process and neglecting the active learning approaches which we think delimits the learning experience. This could further impact the understanding of science process skills.

Recommendation

We have suggested project-based learning inside the experimental classes as an alternative to traditional guided laboratory practices. Project-based learning is a student-centric instructional approach in which the students plan, investigate, and design products (Pokherel, 2022). Instead of employing a laboratory manual teachers are suggested to go for project-based learning which has its roots in constructivist as well as active learning theory.

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