Intelligent Tutoring System Learning Strategy: A Supplemental Interactive Learning Material on Mirrors and Lenses for Grade 10 Science Students

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ABSTRACT

The increasing use of self-learning modules in science education has presented instructional challenges, particularly in teaching abstract topics such as Mirrors and Lenses. This study aims to identify the issues and challenges encountered by Grade 10 science teachers in teaching Mirrors and Lenses using the Department of Education's Self-Learning Module (SLM), examine the coping strategies they employ to address these challenges, and develop a supplemental learning material utilizing an Intelligent Tutoring System (ITS) learning strategy. The study will be conducted in one cluster of the Division of Davao City and will involve twelve (12) Grade 10 science teachers from six (6) public secondary schools selected through purposive sampling. A qualitative descriptive research design will be employed, using a validated Focus Group Discussion (FGD) guide as the primary data collection instrument. The gathered data will be transcribed and analyzed through thematic analysis to identify recurring themes and patterns related to teachers' experiences. Findings from the study will serve as the basis for the development of an ITS-based supplemental learning material designed to provide interactive simulations, step-by-step tutorials, immediate feedback, simplified instructional content, guided learning activities, and a basic AI literacy and verification component. The proposed instructional material is expected to support science teachers in improving students' conceptual understanding and engagement in learning Mirrors and Lenses while complementing the existing self-learning modules.

Keywords: Intelligent Tutoring System, Mirrors and Lenses, Self-Learning Module, qualitative research, science education, supplemental learning material, thematic analysis.

INTRODUCTION

Background of the Study

In the context of 21st-century education, the integration of Artificial Intelligence (AI) into teaching and learning has become increasingly important. Today's learners are expected to develop essential competencies, including critical thinking, communication, collaboration, digital literacy, problem-solving, adaptability, and creativity. Using technology-rich learning environments, these skills are developed more effectively. These digital tools can enhance engagement, support collaboration, and enable a more personalized learning experience. As such, the purposeful use of technology plays a vital role in preparing students to succeed in an increasingly technology-driven society. Ally (2019) emphasizes that technology integration in education promotes flexible, inclusive, and personalized learning experiences that address the diverse needs of learners.

Globally, educational systems are adopting AI-driven tools to improve instructional effectiveness and promote equity. The UNESCO Global Education Monitoring Report (2021) reports that AI in education can support personalized learning, reduce disparities in academic achievement, and contribute to achieving Sustainable Development Goal 4, which focuses on inclusive and equitable quality education. Similarly, Zhai et al. (2021) note that AI-powered platforms, such as Intelligent Tutoring Systems (ITS), provide adaptive and real-time feedback, allowing learners to progress at their own pace and making learning more responsive and effective.

In the Philippine context, the Department of Education (DepEd) has implemented various initiatives to increase access to learning materials, including the distribution of printed Self-Learning Modules (SLMs), particularly during the COVID-19 pandemic when schools shifted to distance learning. These modules continue to be widely used under the K to 12 curriculum, especially in Grades 9 and 10, due to their alignment with the Most Essential Learning Competencies (MELCs) and their function as primary instructional resources in public schools where textbooks are often limited (Department of Education, 2022).

Despite their importance, Self-Learning Modules have several limitations. They are often static, text-heavy, and lack interactivity, making them challenging for many learners, particularly those with low academic performance. Students frequently report difficulty learning independently from the modules, especially when dealing with abstract science concepts such as mirrors and lenses (Andaya, 2021). These difficulties can lead to decreased motivation and widening learning gaps, as students receive limited immediate guidance or feedback. In one secondary school in the Division of Davao City, mirrors and lenses were identified as among the least-learned competencies based on examination results and proficiency levels.

Most existing Self-Learning Modules follow a traditional, one-size-fits-all approach and are not designed to support localized or adaptive instruction. They lack features such as real-time feedback, multimedia elements, and interactive simulations that could enhance conceptual understanding. Moreover, there remains a notable research gap regarding the implementation of Intelligent Tutoring Systems in Philippine basic education, particularly in junior high school Physics. Consequently, there is limited empirical evidence on how Intelligent Tutoring Systems can improve learner engagement, conceptual understanding, and assessment practices in local science classrooms.

In response to these gaps, researchers have advocated for the use of technology-enhanced learning strategies as supplementary interventions to existing Self-Learning Modules rather than as replacements. International studies suggest that Intelligent Tutoring Systems can improve learning outcomes by providing personalized instruction, real-time feedback, and increased learner engagement (Holstein et al., 2019; Nye, 2015). In contexts characterized by large class sizes and limited instructional support, ITS may serve as a valuable tool for supporting both students and teachers.

This study, therefore, aims to examine the challenges teachers face when teaching mirrors and lenses using Self-Learning Modules, and develop a supplemental learning material using Intelligent Tutoring Systems. It is aligned with the university's commitment to developing innovative and contextualized learning materials, and it seeks to contribute to the improvement of science education in the Philippines through the integration of technology-enhanced, AI-supported learning interventions.

Research Questions/Objectives

This study sought to answer the following questions:

1. What are the issues and challenges of Grade 10 science teachers in teaching Mirrors and Lenses using the DepEd's Self-Learning Module?

2. How do Grade 10 science teachers cope with the challenges in teaching Mirrors and Lenses using DepEd's Self-Learning Module?

3. What activities on Mirrors and Lenses can be designed using Intelligent Tutoring Systems learning strategy as supplemental learning material for Grade 10 science students to address the challenges encountered?

Objectives of the Study

1. To identify the issues and challenges of Grade 10 science teachers in teaching Mirrors and Lenses using the DepEd's Self-Learning Module.
2. To find out how Grade 10 science teachers cope with the

challenges in teaching Mirrors and Lenses using DepEd's Self-Learning Module.

3. To determine the activities on Mirrors and Lenses that can be

   designed using the Intelligent Tutoring Systems learning strategy as supplemental learning material for Grade 10 science students to address the challenges encountered.

Significance of the Study

The results of the study can be beneficial to the following:

Students. Today and in recent years, there has been a higher use of technology in society. Students are surrounded by technology and are involved in Artificial Intelligence (AI), especially in the field of education. Thus, in this study, students are the main recipients of the Intelligent Tutoring System-based supplementary learning material that utilizes Artificial Intelligence (AI). This may provide a more personalized learning experience that can adapt to each student's learning needs and at their own pace, fostering better understanding and engagement in science.

Science Teachers. Using Intelligent Tutoring Systems as an innovative tool may enhance the science teacher's skills in technology. It may support traditional teaching strategies, which may lessen the burden of the teaching-learning process. It may also offer them other strategies to teach the students.

School Administrators. The results of this study may provide school administrators with insights into the strengths and limitations of Intelligent Tutoring Systems as supplemental learning material. These findings may assist in identifying teachers' training needs and in planning appropriate professional development initiatives. Additionally, the study may support efforts to promote technology-driven instruction through the integration of digital learning solutions into the curriculum.

Researchers. This study may serve as a groundwork for future developments on the effectiveness of Intelligent Tutoring Systems in science education, specifically in teaching mirrors and lenses. Moreover, it may provide data on the effectiveness of Intelligent Tutoring Systems that use Artificial Intelligence in the engagement of students in learning mirrors and lenses.

REVIEW OF LITERATURE AND THEORETICAL FRAMEWORK

Related Literature and Studies

This section presents all the relevant and related literature and studies that provide the theoretical and empirical foundation for this research.

Intelligent Tutoring Systems

Intelligent tutoring systems emerged as a revolutionary educational technology that introduces and makes use of artificial intelligence to act as human tutors to support individualized learning. This system is designed to assess the student's needs, adapt the lesson content, and then provide feedback to guide the learning process to maximize learning objectives.

As defined by Mousavinasab et al. (2021), an Intelligent Tutoring System is a computer-based instructional system that highlights and makes use of Artificial Intelligence (AI) and machine learning (ML) by imitating a human tutor to provide customized learning. It is designed to create a learning environment that is adaptive to respond to each individual's own pace, style, and level of understanding.

Furthermore, Pu, J. et al. (2024) emphasized that intelligent tutoring systems can use the student's previous data, analyze it thoroughly, and design and deliver a variety of intelligent learning services that will effectively support personalized learning.

Moreover, according to Spitzer et al. (2024), one of the core features of intelligent tutoring systems is their ability to log and analyze data that is generated during the interactions between the students and the system. In their study, they have put great emphasis on the importance of the process data as it plays a critical role in informing the instructional decisions in intelligent tutoring systems. Through the continuous interactions of the student and the system, intelligent tutoring systems can create a learning environment that is adaptive, which will support the mastery of the topic and improve long-term retention.

In addition, according to Zhai et al. (2021), integrating Artificial Intelligence (AI) in education, such as Intelligent Tutoring Systems, is a powerful innovation, since it can simulate one-on-one instruction, and it can deliver personalized, adaptive, and real-time feedback to the students.

Moreover, according to Holstein, McLaren, and Aleven (2019), Intelligent Tutoring Systems support teachers by providing data to guide interventions that are personalized to cater to each student's needs. Intelligent Tutoring Systems, when used as a supplement to traditional instruction, enhance student engagement and allow for independent learning, making it a suitable approach for improving comprehension in science education.

Furthermore, in the context of 21st-century education, according to Care et al. (2018), integrating Artificial Intelligence (AI) technologies such as Intelligent Tutoring Systems will not only promote digital literacy but can also address challenges in differentiation instruction.

Aside from individualized learning, intelligent tutoring systems have developed to facilitate collaborative learning. Systems like ALEKS and AutoTutor have been widely utilized to promote inquiry-based, self-paced learning in mathematics and science while fostering metacognition and critical thinking (Graesser et al., 2018).

Furthermore, in a broader review, Intelligent Tutoring Systems, according to Verdú et al. (2017), represent one of the most important advancements in educational technology that are designed to simulate the adaptive nature of humans using artificial intelligence. It makes use of advanced logarithms, and it can assess and respond to an individual's own pace, style, and level of learning. It provides a personalized learning pathway to adjust to the individual's learning needs based on the learner's responses, and it provides immediate feedback in real-time.

Similarly, Intelligent Tutoring Systems was shown to be as effective as human tutors in a study conducted by VanLehn et al. (as cited in Nye, 2015), in delivering personalized lessons to the students, specifically in addressing complex concepts in science.

On the other hand, in physics education, students often encounter difficulties in learning abstract topics like optics, motion, and energy. For instance, the topic on Mirrors and Lenses requires visualization for the students and spatial reasoning skills that are not easily supported by printed materials alone. To improve the clarity of the concepts and, at the same time, reduce the misconceptions would often require simulations, animations, and guided inquiry, according to Zhu & Zhai (2022), and all of these can be integrated into Intelligent Tutoring Systems platform.

Furthermore, international studies have demonstrated that Intelligent Tutoring Systems have the potential to improve learning outcomes in science and physics education. Zhu and Zhai (2022) created and assessed an AI-based physics tutoring system that is designed to solve the problem of students' misconceptions in optics. The study has revealed a positive improvement in the understanding of the students in image formation by using mirrors and lenses. Also, it not only improves short-term gain, but also long-term gain, since the students not only demonstrated better performance in immediate post-tests, but also in delayed assessments.

In addition, in a meta-analysis of the effectiveness of Intelligent Tutoring Systems across the K to 12 education conducted by Zhai et al. (2021), findings showed that students who used Intelligent Tutoring Systems have greater improvements in learning outcomes compared to those who used traditional instruction alone. This is more pronounced in subjects like physics, where conceptual understanding plays a crucial role.

In addition, local applications of intelligent tutoring systems in science education have shown similarly promising results. Guevara and Ignacio (2021) investigated how a prototype intelligent tutoring system was

included in Earth Science curricula in a few public schools. According to their findings, after engaging with Intelligent Tutoring Systems courses, students showed an increased ability to comprehend abstract ideas like plate boundaries and continental drift. Increased learner autonomy and interest in science-related tasks were also seen by the researchers.

Similarly, in the Philippine context, research on the utilization of Intelligent Tutoring Systems is still emerging. Teachers' experiences with modular learning during the pandemic were examined by Andaya (2021), who also underlined the necessity of interactive and adaptable tools that can help students in low-resource settings. Even though Intelligent Tutoring Systems are not yet often used in nearby schools, research like this indicates that implementing AI-supported systems could be a good way to deal with current issues in science and modular education.

In addition, the use of an intelligent tutoring application among junior high school science students in the Philippines was investigated by Fernandez and Lapuz (2020). The findings showed that students who used the system demonstrated significantly higher conceptual understanding and motivation than those who received traditional classroom instruction. Additionally, the researchers noted that students' self-efficacy and confidence improved as a result of receiving immediate, scaffolded feedback.

Furthermore, in a study conducted by Kulik and Fletcher (2016), their findings showed that intelligent tutoring systems have a considerable positive impact on the students' learning outcomes, specifically if the system is aligned with the objectives and assessments. In addition, intelligent tutoring systems must be carefully designed and properly implemented to achieve accurate and high-quality results.

METHODOLOGY

This chapter discusses the methodologies that will be utilized in the study, such as the research design, sources of data, data gathering instrument, sampling technique, procedure of the study, and the statistical treatment.

Research Design

This study will employ a qualitative research method and will utilize a descriptive case study design to explore the issues and challenges encountered by Grade 10 science teachers in teaching Mirrors and Lenses using the DepEd Self-Learning Module, as well as the coping strategies they employed. Qualitative research focuses on exploring and understanding complex phenomena and the meanings attributed by individuals or groups to them (Creswell & Poth, 2018). In this study, a qualitative descriptive case study research design will be used to investigate the issues and challenges faced by Grade 10 science teachers while using DepEd's Self-Learning Module on Mirrors and Lenses.

Research Instrument

The primary data-gathering instrument that will be used in this study is a researcher-developed Focus Group Discussion (FGD) guide questionnaire. The instrument will be developed based on the objectives of the study and will be focused on identifying teachers' experiences, challenges, instructional practices, and perceived limitations of the DepEd Self-Learning Module in teaching Mirrors and Lenses.

To establish content validity, the FGD guide questionnaire will be reviewed and validated by four (4) science education experts. Their suggestions and recommendations will be incorporated to improve the clarity, relevance, and alignment of the questions with the objectives of the study.

Sources of Data

The participants of the study will be the Grade 10 science teachers teaching Mirrors and Lenses in six (6) secondary public schools in Davao City, from one of the clusters in the division of Davao City, through Focus Group Discussion (FGD). The qualitative data will be a purposive sample of twelve (12) teachers, wherein in each school, two (2) science teachers participated– one (1) science teacher and one (1) master teacher or department head.

Participants in the study should meet the following criteria: taught grade 10 science and directly handled the topic of mirrors and lenses; were assigned to one of the six (6) selected public secondary schools; and held positions as either a science teacher or a Master Teacher, or a Department Head.

Participants who will be excluded from the study will be the teachers who did not teach grade 10 science or did not handle the topic on mirrors and lenses, and who were not teaching in the selected public schools.

The primary sources of data will be the Focus Group Discussions (FGDs) to provide deeper insights.

Sampling Technique

The qualitative data for the study will be gathered using a purposive sampling. This non-probability sampling technique involves selecting participants who meet specific, pre-established criteria relevant to the research objectives. In this study, participants will be chosen based on their direct experience with the DepEd Self-Learning Module on Mirrors and Lenses as Grade 10 Science teachers. This method ensures that the selected individuals can provide rich, relevant, and in-depth insights into the issues and challenges explored in the study (Palinkas et al., 2015).

Procedure of the Study

Asking Permission to Conduct the Study. The researcher will obtain the needed approvals as well as the permissions from the authorities, including the Dean of the College of Education, the Department of Education Davao City Divisions Superintendent, the Schools Division Superintendent/Principal-In-Charge in the Cluster, and the Principal of one of the secondary schools in Davao City.

Creation of the Focus Group Discussion (FGD) Questionnaire. The FGD questionnaire will be created by following the objectives of the study.

Validity Test of the Focus Group Discussion (FGD) Questionnaire. The FGD questionnaire will be checked and approved by four experts in the field of science.

Administration of the Focus Group Discussion. The focus group discussion using the validated FGD questionnaire will be conducted in the six (6) selected schools in one of the clusters in the division of Davao City. It will be composed of twelve (12) science teachers, according to the criteria given to gather information on the issues and challenges they have encountered when using the self-learning module on Mirrors and Lenses and the lesson itself. Before the conduct of the focus group discussion (FGD), the participants will be informed about the study's objectives and will be assured that their responses will be confidential. They will also receive the needed consents.

Conduct of the Study. The results of the focus group discussion (FGD) of the grade 10 science teachers on DepEd's self-learning module on Mirrors and Lenses, and after identifying the issues and challenges they encountered while using it, activities will be developed using the learning strategy called Intelligent Tutoring Systems that uses Artificial Intelligence (AI), as a supplemental learning material.

Analysis and Interpretation of Data. The results will be tabulated for thematic analysis, and the gathered data will be interpreted.

Data Analysis

In this study, the qualitative data gathered from the Focus Group Discussions (FGDs) will be analyzed using reflexive thematic analysis following the framework of Braun and Clarke (2022). The process will involve familiarization with the data, generation of initial codes, searching for themes, reviewing and refining themes, defining and naming themes, and producing the final report. This approach is appropriate for identifying patterns of meaning across participants' experiences and addressing the research objectives.

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Bionote

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