# Adaptive E-Learning Module In Teaching Physical Science For Improved Student Engagement And Critical Thinking Skills

**Shirley Handog[1], John Vincent Aliazas[2]**
[1]Hinguiwin National High School, Padre Burgos, Quezon, Philippines
[2]Laguna State Polytechnic University, San Pablo City, Philippines

***Abstract-*** *The research aimed to improve student engagement and critical thinking skills using the adaptive e-learning module in teaching physical science. Specifically, it soughtto determine the challenges encountered by the students in using the e-learning module, the perception of the respondents in different features of the e-learning module, the overall acceptability of the e-learning module, the level of students' critical thinking skills and the student's engagement in physical science; ascertain the significant difference on the level of students' critical thinking skills before and after using the adaptive e-learning Module and significant relationship between the developed e-learning module and the student level of engagement in physical science. The study used an experimental approach to enhance students' critical thinking skills and engagement. The developed e-learning module focuses on the least learned topic and competencies in physical science. The respondents were composed of 50 students undergoing experimentation. Hence, the respondents strongly agreed that the adaptive e-learning module is accessible, an excellent source of information and contains technical support for the learners and interactive lessons, video lessons and simulations that enhance students' learning. The e-learning module is commendable as an innovative way of teaching, effectively improving learners' engagement and critical thinking skills. The results illustrate the significant difference in students' critical thinking skills before and after using the e-learning module and the significant relationship between the developed adaptive e-learning module and student engagement in Physical Science.*

***Keywords***- critical thinking skills, student engagement, adaptive e-learning module, teaching physical science

## I. INTRODUCTION

Physical science forms an integral part of the secondary school curriculum; it aims to improve students' knowledge and understanding of their physical world, enabling them to meet human needs and use the environment sustainably. Physical science studies biological and chemical phenomena. It achieves this through scientific inquiry, utilizing scientific models, hypotheses, and laws to elucidate and forecast occurrences in the physical realm. The statement emphasizes the importance of society comprehending the functioning of the physical environment to utilize and maintain it effectively (DoBE, 2020).Physical science revolves around curiosity and inquiry. Individuals contemplate the reasons behind phenomena, their interconnections, and the mechanisms responsible for the transformations occurring in their environment. Understanding physical science enables scientists to make future predictions. The student must be interested in natural phenomena and able to solve problems related to science, technology, and the environment (Zumdahl, 2018). Physical science enhances understanding and abilities in scientific investigation, problem-solving, and developing and utilizing scientific and technological information.

Society's challenges are tackled by utilizing all existing scientific and technological expertise and indigenous knowledge systems. Learning and teaching should be more like playing, where both activities are concurrently seen to work with the learning having an instant practical application (Panergayo & Aliazas, 2021). Thus, it can be concluded that Physical Science is a crucial subject at the secondary level, even though teachers frequently struggle to explain and teach its concepts. If these concepts, which are challenging for teachers to understand, are trained to students, they will be transmitted incorrectly, leading to the development of numerous alternative conceptions. Teachers must possess a strong understanding of the subject matter and be adaptable to teach modern physical science principles effectively (Montilla et al., 2023). This will help teachers support students in creating effective cognitive maps, linking concepts, and dealing with different conceptions (Chavan, 2018).

Currently, the utilization of diverse technologies to improve education in technology-enhanced learning is prevalent. Various reasons drive this advancement. Schweighofer (2018) found multiple papers that discuss the importance of technology-enhanced learning methods. The

selected papers assert that these strategies are essential for thriving in the contemporary digital economy. As people are accustomed to utilizing technologies, they want educational settings that incorporate them. Technology-enhanced learning is a comprehensive word encompassing all methods where technology is utilized to aid in learning or teaching. Terms such as e-learning, online learning, game-based learning, and web-based learning are all part of the research area known as technology-enhanced education.

E-learning materials like e-books and e-modules are advanced educational resources designed at a high scientific and methodological standard. They are primarily used for presenting new information, complementing printed materials, facilitating individualized training, and assessing a student's knowledge and skills to some extent. E-learning products guide students in an independent educational pursuit focused on self-regulation and self-evaluation of learning.

Physics e-learning modules can enhance students' critical thinking abilities by prompting them to search for concepts autonomously. The research conducted by Febrianti et al. (2017) supports the suitability of the physics digital modules for students to use as self-learning materials.

Adaptive e-learning module application with the ultimate digital publishing feature for education and training. The ability to develop rich interactive material that runs in various formats or even in one's custom-branded app is provided to users. It also enables other users, such as students, to access the content online or offline based on their capabilities and access the necessary resources. Adaptive e-learning modules would be a big help to students, especially those who favored modular distance learning, in this new normal of the educational system.

Adaptive e-learning modules are designed for individuals looking to acquire digital marketing skills or improve their existing ones. The courses are self-paced, and learners can access them from anywhere at any time. The adaptive e-learning module platform also includes interactive exercises, quizzes, and assessments to help learners apply what they have learned and track their progress. Adaptive e-learning module provides certifications upon completion of each course, which can be shared on social media or added to a resume.

**Background of the Study.**Several stakeholders, such as instructors, parents, learners, and the Department of Education, have raised concerns about the subpar performance of Grade 12 students in Physical Sciences. It is caused by insufficient communication skills between learners and educators in the language of instruction, absence of creative teaching methods, inability to utilize e-learning tools in teaching Physical Science, lack of expertise, and shortage of material resources.

Throughout history, learners have used several tools and techniques to efficiently and quickly enhance their learning process. Various elements can impact teaching in educational contexts. One factor is the utilization of contemporary technologies in educational settings. E-learning modules offer advanced infrastructure for disseminating knowledge in various ways across different locations and to diverse learners, considerably influencing human existence from multiple viewpoints.

Different difficulties may cause hindrances in continuing the teaching and learning process because of the pandemic's widespread effect, which deals with the low performance of the students as they only depend on the learning modality that fits their current situation (Javier &Aliazas, 2022). The learners may develop poor-quality education as they do not practice developing higher-order thinking skills and are primarily dependent on the textbook and improper use of technology in learning.

Students at Elias A. Salvador National High School, where the researcher teaches, struggle to understand the Physical Science lesson. The student's performance in physical science is relatively poor, based on the learners' three-year mean percentage score. For the academic years 2019-2020 and 2020-2021, the mean percentage score is 35.08 percent and 33.2 percent, respectively. The average percentage score for the academic year 2021-2022 is 36.5 percent. Furthermore, the current school year 2022-2023 has a first quarter mean percentage score of 40.5 percent, emphasizing the need for intervention and innovative approaches to teaching physical science.

Furthermore, as the researcher's observations show, the learners struggle to comprehend the relevant learning area because they do not understand the concepts. During the assessment, most students can answer identification, multiple choice, and true/false questions. Still, they struggle with problem-solving, which is commonly used. They need higher-order thinking skills, and most find it difficult to answer.

As a result, the researcher prefers to improve students' critical thinking skills through e-learning modules in physical science classes. Students frequently struggle with subjects such as science, particularly physics. However, there are numerous methods for dealing with and uncovering their difficulties. One method for overcoming these challenges is to

use the NODMA-based e-learning module, which allows them to apply their newly acquired knowledge through various interactive lessons and simulations. The e-learning module assists them in applying their learnings practically and developing a process for evaluating their understanding. Applying the concept in a real-world situation is an example of critical thinking, as is using the idea learned in an interactive and virtual laboratory simulation. This process involves learning by doing, based on the constructivist theory of developing students' critical thinking.

This study aimed to improve the students' engagement and critical thinking skills through the Adaptive E-learning Module in Teaching Physical Science.

Specifically, it sought to answer the following questions:

1. To what extent do the students encounter challenges in using the adaptive e-learning module in Physical Science in terms of
   1.1 access;
   1.2 resources; and
   1.3 technical support?
2. What is the perception of the respondents of using the different features of adaptive e-learning modules in terms of:
   2.1 interactive E-learning module;
   2.2 video lesson; and
   2.3 simulation?
3. What is the overall acceptability of the adaptive e-learning module in terms of:
   3.1 content quality;
   3.2 instructional quality; and
   3.3 technical quality?
4. What is the level of student's critical thinking skills in terms of:
   4.1 applying;
   4.2 analyzing;
   4.3 evaluating; and
   4.4 creating?
5. What is the level of student engagement in Physical Science in terms of:
   5.1 motivation;
   5.2 engagement in learning;
   5.3 5.3 meaningful communication; and
   5.4 problem-solving?
6. Is there a significant difference in students' critical thinking skills before and after using the adaptive e-learning module?
7. Is there a significant relationship between the developed adaptive e-learning modules and the student level of engagement in Physical Science?

## II. METHODOLOGY

***Research Design***.This study employed the experimental methodology as a scientific method when analyzing many variables. The experiment aims to establish the cause-and-effect relationship between certain variables. This study enhanced students' critical thinking skills and engagement by utilizing an adaptive e-learning module to teach physical science. The researcher developed an e-learning module that emphasizes the least-covered topic and competencies in physical science.

***Respondents of the Study.***The sample consisted of 50 grade 12 students from Elias A. Salvador National High School. They were chosen through purposive sampling from five sections equally divided as respondents, and most of them deal with difficulties in Physical Science based on their performance in the subject.

***Research Instruments***. The instrument used in this research was a questionnaire to determine the challenges in using adaptive e-learning modules, pre-test/post-test, and development of eLearning modules in physical science.

Construction of Adaptive E-Learning Module. The researcher created the eLearning module to improve students' engagement and critical thinking skills. The term "eLearningModule" refers to the learning module with various subtopics used by grade 12 physical science students. The e-learning module comprised several components: an interactive science simulation, a virtual laboratory simulation, and a video lesson. To meet the needs of the students, the learning activities included knowledge, understanding, process/skill, and product/performance. The e-learning module has been validated for evaluators' comments and suggestions to improve the e-learning module.

Utilization of Adaptive E-learning module in teaching Physical Science. The researcher utilized the adaptive e-learning module to the respondents to improve students' engagement and critical thinking of the learners, referring to applying, analyzing, evaluating, and creating. It comprised different features that developed the learners' skills and helped the teacher enhance the student's critical thinking.

Students Engagement in Physical Science. The researcher used a questionnaire to identify the students' engagement in Physical Science. The researcher presented the questionnaire to the science teachers for further comments, suggestions, and recommendations for face validation using the adaptive e-learning module in Physical Science in a Likert

with 20 statements referring to motivation, engagement in learning, meaningful communication and problem-solving.
Pre-test/Post-test. This phase involved the development and validation of the pre-test/post-test. These were explained as follows:

1.Development of the Pre-test/Post-test. The researcher prepared a 40-item test that has undergone validation by science teachers for further comments, suggestions, and recommendations.

2.Validation of the Test. The constructed test was tried first on grade 12 students of Elias A. Salvador NHS for validation. The test result will undergo item analysis to determine the difficulty and discrimination index.

***Research Procedure***. Developing and verifying an adaptive e-learning module. The researcher requested permission from the principal of Elias A. Salvador National High School, Agdangan, Quezon, to conduct the research. The researcher will prepare the required tools to collect participant data following permission. Respondents were given a pre-test before the e-learning module experiment to enhance learner engagement and critical thinking skills. Two groups, an experimental group and a control group, were utilized in the investigation. The participants had completed a pre-test to identify the topic and competence with the lowest level of understanding. The experimental group experimented with the designed e-learning module, while the control group received instruction through traditional teaching methods.

After the experimentation, the post-test was administered to the respondents using the adaptive e-learning module in teaching physical science and lesson presentation. After experimentation, the researcher determined the challenges using the developed e-learning module. After administering instruments, the data were tallied, tabulated, analyzed and interpreted.

Regarding ethical considerations, informed consent applies to the study since the study uses human subjects or respondents. The study does not involve any vulnerable sector as its respondents. The researchers described the Informed Consent Process, including the informed consent obtained attached to the first part of the survey questionnaire. The informed consent was documented safely.

Furthermore, it is commonly accepted that recruiting procedures should provide ample time for a detailed explanation of the study to prevent pressure or undue influence, allowing potential participants to carefully assess the facts before deciding on participation.

The last part of the consent form states they can terminate their involvement at anytime. The researcher's email address and contact number are also provided if the respondent wishes to revoke their answer.

The study mainly focuses on improving learners' engagement and critical thinking in Physical science. The participants were informed about the study's purpose, risks, benefits, and objectives and their responses' privacy, anonymity, and confidentiality. The researcher had assigned participants codes/numbers that had been used in all research notes and documents.

***Statistical Treatment.***The collected data was carefully recorded, counted, and examined. A paired t-test was utilized to assess the statistical significance of the difference between the pre-test and post-test scores of the participants. The test requires calculating the differences between data pairs, determining the mean and standard deviation of the difference scores, and then computing the t-value using a specific formula. The T-test for dependent samples, or paired sample t-test, is a statistical method used to compare the means of two populations. It is utilized in "before and after" research, matched paired samples, or controlled investigations. The degrees of freedom and critical value were calculated to compare the t-value and determine if the null hypothesis should be rejected.

The Pearson correlation was utilized to establish the substantial association between the produced adaptive e-learning module and the researcher's level of engagement in physical science. The Pearson correlation coefficient is a statistical measure that outlines the characteristics of a dataset. It defines the magnitude and orientation of a linear correlation between two numerical variables. The most widely used technique for computing a linear correlation. The correlation coefficient, ranging from -1 to 1, represents the magnitude and direction of the relationship between two variables. The variables' outcomes were compared to the condition. Suppose both variables are measured on an interval or ratio scale. Thus, both variables exhibit normal distributions and do not contain any outliers. If the p-value is low (usually less than 0.05) or the calculated value exceeds the p-value in the r-table at a particular significance level.

## IV. RESULTS AND DISCUSSION

**Table1**. Challenges Encountered by the Students in Using the Adaptive E-learning Module in Physical Science in Terms of Access

| Indicators | M | SD | VI |
|---|---|---|---|
| 1. The module is available to access as an eLearning module. | 3.98 | 0.14 | Strongly Agree |
| 2. Smartphones and laptops are compatible with the adaptive e-learning module. | 3.92 | 0.27 | Strongly Agree |
| 3. Adaptive e-learning module is adequate for internet access. | 3.9 | 0.30 | Strongly Agree |
| 4. The cost of internet usage in accessing adaptive e-learning is low. | 3.92 | 0.27 | Strongly Agree |
| 5. The adaptive learning module is easy to access. | 3.88 | 0.33 | Strongly Agree |
| Overall | 3.92 | 0.19 | Strongly Agree |

*Legend: 3.50–4.00 (Strongly Agree/Highly Acceptable); 2.50–3.49 (Agree/Acceptable); 1.50–2.49 (Disagree/Slightly Acceptable); 1.00–1.49 (Strongly Disagree/Not Acceptable).*

Table 1 reflects the respondents' evaluation of the Alzahrani ges encountered by the students in using the adaptive e-learning module in Physical Science to access. The obtained weighted mean for all the items in the access of the e-learning module ranged from 3.88 to 3.98, proving the adaptive e-learning module is accessible on the part of the students.

Among indicators, statement 1 (The module is available to access as an E-learning module) is rated highest with a 3.98 weighted mean and standard deviation of 0.14 described as strongly agree. The adaptive e-learning module is available for students to understand the concept of physical science comprehensively. The adaptive e-learning module offers limitless learning opportunities for students and is a novel approach to educating 21st-century learners. Trilestari et al. (2020) found that adaptive e-learning modules can enhance accessibility, allowing students to access digital knowledge anytime using their devices, thus enriching their learning experiences.

Statement 5 (The adaptive e-learning module is easy to access), the least among the five items with a weighted mean of 3.88, falls under strongly agree as qualitative description. The adaptive e-learning module is easily accessible by the students for effective and improved learning outcomes. The easily accessible e-learning module provides better outcomes for the learners. This supports the study of Chen et al. (2020), revealing the accessibility of e-learning modules is an essential aspect to consider when designing and developing online courses. Providing inclusive and accessible digital learning environments can improve the learning experience and outcomes for all students, including those with disabilities or diverse learning needs.

E-learning can improve student engagement retention and foster more inclusive and equitable learning environments by reducing obstacles to access and participation. Therefore, the respondents strongly agree with a 3.92 mean. Findings confirm that accessible e-learning environments benefit all students by increasing engagement, retention, and overall learning results. This supports the study of Zhang et al. (2020), revealing that the accessibility of e-learning modules can substantially impact all students' learning experiences and outcomes.

**Table2**. Challenges Encountered by the Students in Using the Adaptive E-learning Module in Terms of Resources

| Indicators | M | SD | VI |
|---|---|---|---|
| 1. The adaptive e-learning module is a good source of intervention in teaching selected topics in Physical Science. | 3.96 | 0.20 | Strongly Agree |
| 2. The adaptive e-learning module contains features that promote critical thinking. | 3.82 | 0.44 | Strongly Agree |
| 3. Adaptive e-learning module contains simulation that promotes the learners' engagement. | 3.84 | 0.37 | Strongly Agree |
| 4. The adaptive e-learning module is an opensource technological tool for learning. | 3.80 | 0.40 | Strongly Agree |
| 5. The adaptive e-learning module is a platform to be used for free by the learners. | 3.96 | 0.20 | Strongly Agree |
| Overall | 3.876 | 0.16 | Strongly Agree |

*Legend: 3.50–4.00 (Strongly Agree/Highly Acceptable); 2.50–3.49 (Agree/Acceptable); 1.50–2.49 (Disagree/Slightly Acceptable); 1.00–1.49 (Strongly Disagree/Not Acceptable).*

Table 2 shows the respondent's evaluation of challenges encountered by the students in using the adaptive e-learning module in Physical Science as a resource. The obtained weighted mean for all the items in the resources of the e-learning module ranged from 3.80 to 3.96, proving the adaptive e-learning module is a source of information and knowledge in learning on the part of the students.

Statement 1 (The adaptive e-learning module is a good source of intervention in teaching selected topics in Physical Science) and statement 5 (The adaptive e-learning module is a platform that learners can use for free) are rated as strongly agree with a 3.96 mean and a standard deviation of 0.20. Adaptive e-learning modules can be an effective intervention tool in various educational processes. They give learners flexibility regarding time, pace, and location and multimedia-rich and interactive learning resources that can boost engagement and motivation. Furthermore, technological advancements have made it possible to create and distribute free e-learning modules that provide high-quality educational resources to learners worldwide. These free tools make gaining knowledge and skills easier and less expensive, making education more inclusive and equal. This is similar to Toma and Marinescu's (2019) work, which described how free e-learning modules can democratize access to education and improve social inclusion by allowing learners to acquire knowledge and skills regardless of geographical location or socioeconomic status. These resources can help bridge the digital divide and reduce educational inequality globally.

With a mean of 3.80, Statement 4 (The adaptive e-learning module is an opensource technological tool for learning) falls under strongly agree as qualitative description. The statement addresses the e-learning module as a powerful open-source technical solution enabling learners to access high-quality educational resources anytime and from anywhere. Furthermore, open-source e-learning modules are inexpensive because they do not necessitate costly licensing fees or proprietary software. Because they can create and share high-quality educational resources at a fraction of the cost, they are an ideal solution for institutions and educators with limited budgets. According to Garcia et al. (2018), opensource e-learning modules can encourage collaboration, innovation, and information exchange among educators and learners. By allowing the reuse, modification, and redistribution of educational resources, open-source e-learning can foster a culture of lifelong learning, stimulate creativity and diversity in learning materials, and support the development of innovative pedagogical techniques. As a result, the respondents strongly agree with a 3.876 average weighted mean. The findings confirm that the adaptive eLearning module promotes a diverse way of learning by removing barriers, allowing all learners to use the e-learning module for free, and containing features that develop their critical thinking. According to Al-Emran (2019), e-learning modules provide learners various interactive and multimedia-rich learning materials that offer a comprehensive and engaging learning experience. These resources can help learners acquire and retain knowledge, develop critical thinking skills, and increase motivation and engagement with course material.

**Table3**. Challenges Encountered in Using the Adaptive E-learning Module in Terms of Technical Support

| Indicators | M | SD | VI |
|---|---|---|---|
| 1. The Adaptive e-learning module contains clear instructions to use the different features. | 3.94 | 0.24 | Strongly Agree |
| 2. The adaptive e-learning module has step-by-step procedures to manipulate simulations. | 3.88 | 0.33 | Strongly Agree |
| 3. Adaptive e-learning module provides instruction on simple troubleshooting in the program. | 3.94 | 0.24 | Strongly Agree |
| 4. The adaptive e-learning module contains the teacher's contact details for the different queries related to the lesson. | 3.94 | 0.24 | Strongly Agree |
| 5. The adaptive e-learning module has a technical support feature for the user's queries. | 3.86 | 0.35 | Strongly Agree |
| Overall | 3.91 | 0.16 | Strongly Agree |

*Legend: 3.50–4.00 (Strongly Agree/Highly Acceptable); 2.50–3.49 (Agree/Acceptable); 1.50–2.49 (Disagree/Slightly Acceptable); 1.00–1.49 (Strongly Disagree/Not Acceptable).*

Table 3 illustrates the respondent's evaluation of challenges encountered by the students in using the adaptive e-learning module in Physical Science as to technical support.

The obtained mean for all the items of the e-learning module ranged from 3.86 to 3.94, proving the adaptive e-learning module contains information for technical support to the learners.

The e-learning module contains information that provides technical support to learners on simple troubleshooting and instructions on using various e-learning module features. Statement 1 (Adaptive e-learning module has clear instructions to use the different components), statement 3 (Adaptive e-learning module provides education on simple troubleshooting in the program), and Statement 4 (The adaptive e-learning module contains contact details of the teacher for the various queries related to the lesson) are rated as strongly agree with a 3.94 mean and standard deviation of 0.24. This is similar to Patil et al.'s (2020) work. Adequate technical support is critical to the success of e-learning initiatives. When e-learners face technical difficulties, having prompt and easily accessible technical support can help them overcome these obstacles, resulting in a better learning experience. This can increase course satisfaction, engagement, and course material retention.

Statement 5, (The adaptive e-learning module has a technical support feature for the user's queries), with a weighted mean of 3.86, falls under the category of strongly agree as a qualitative description. The statement discusses the significance of technical support when using any e-learning module to answer learners' questions about problems with the adaptive module. Technical support that is responsive and accessible is critical to the success of e-learning programs, and it can have a significant impact on students' engagement, satisfaction, and retention of course content. If students encounter technical difficulties during the course, having effective technical support can assist them in overcoming these obstacles and improving their overall e-learning experience. This contributes to Najjar's work (2019).
As a result, the respondents generally agree with a 3.91 average weighted mean.

The results confirm that the adaptive e-learning module contains clear instructions, step-by-step procedures, instructions, technical support, and details for the various lesson queries. This is in line with the work of Ali et al. (2018). A dependable technical support system is an essential component of e-learning programs. Ensuring that learners succeed and are happy with their learning experience is crucial. Effective technical support should be easily accessible, responsive, and user-friendly, providing learners with timely solutions to their technical problems and concerns.
Table 4 on the following page shows the respondents' perceptions of using the various features of adaptive e-learning modules in terms of the interactive e-learning module. The obtained weighted mean for all e-learning module items ranged from 3.90 to 3.96, demonstrating that the adaptive e-learning module contains interactive features that provide learners with an innovative way of learning.

Statement 1 (The E-learning module contains an interactive way of teaching selected topics in physical science), statement 3 (The E-learning module includes a step-by-step process of performing different activities for more comprehensive learning), and statement 5 (The interactive E-learning module gives additional information that broadens my knowledge of the lesson) are rated the highest among indicators, with a 3.96 weighted mean and standard deviation of 0.20.

**Table4**. Use of Adaptive E-learning Module in Terms of Interactive E-Learning Module

| Indicators | M | SD | VI |
|---|---|---|---|
| 1. The E-learning module contains an interactive way of teaching selected topics in physical science. | 3.96 | 0.20 | Strongly Agree |
| 2. Learning using the adaptive e-learning module creates a new classroom that innovates teaching. | 3.90 | 0.30 | Strongly Agree |
| 3. The e-learning module contains the step-bystep process of performing different activities for more comprehensive learning. | 3.96 | 0.20 | Strongly Agree |
| 4. Using the e-learning module helps students understand the lesson more easily. | 3.94 | 0.24 | Strongly Agree |
| 5. The interactive E-learning module gives additional information that widens my knowledge of the lesson. | 3.96 | 0.20 | Strongly Agree |
| Overall | 3.944 | 0.12 | Strongly Agree |

*Legend: 3.50–4.00 (Strongly Agree/Highly Acceptable); 2.50–3.49 (Agree/Acceptable); 1.50–2.49 (Disagree/Slightly Acceptable); 1.00–1.49 (Strongly Disagree/Not Acceptable).*

Because of their ability to improve student engagement, critical thinking skills, and knowledge retention,

interactive e-learning modules have grown in popularity. These modules include interactive components such as videos, animations, and gamification, which provide learners with a personalized and engaging learning experience that encourages exploration and active participation. This approach promotes a more immersive learning environment better suited to meet students' diverse learning styles and preferences. The results are similar to Aldahdouh's work (2021).

Statement 2 (Learning using the adaptive e-learning module creates a new classroom that innovates teaching), with a weighted mean of 3.90, falls under the category of strongly agree as a qualitative description. The e-learning module immerses the learner in a new classroom environment that promotes individual learning and interacts with the learners to help them continue their education. Furthermore, because they are more engaged and actively involved in learning, learners are more likely to retain information learned through interactive e-learning modules. This demonstrates how interactive eLearning modules Shah et al. developed (2021) can create an innovative classroom environment. The interactive e-learning module contains components such as multimedia, gamification, and simulations that can aid in the creation of a student-centered learning environment that promotes creativity, collaboration, and critical thinking. Furthermore, interactive e-learning modules can provide teachers with real-time feedback on student performance, allowing for rapid intervention and personalized instruction.

As a result, the respondents generally agree with a 3.944 average weighted mean. The findings confirm that the adaptive e-learning module includes interactive lessons, creates an innovative classroom environment for more comprehensive learning, and broadens learners' knowledge of the topic of physical science. The learners' impression aligns with Zia's (2018) findings, indicating that a high-quality electronic physics module offers advantages by facilitating comprehension of physics ideas and fostering connections in learning. Physics in daily life can serve as a diverse educational resource to motivate students to study autonomously, innovatively, and efficiently to attain mastery of skills, resulting in desired learning outcomes.

**Table5**. Use of the Adaptive E-learning Module in Terms of Video Lesson

| Indicators | M | SD | VI |
|---|---|---|---|
| 1. The video lesson in the adaptive e-learning module is relevant to the topic. | 3.98 | 0.14 | Strongly Agree |
| 2. Adaptive e-learning module contains video lesson that enhances learning. | 3.98 | 0.14 | Strongly Agree |
| 3. The adaptive e-learning module video lesson propounded my knowledge about the selected topic in physical science. | 3.84 | 0.37 | Strongly Agree |
| 4. The video lesson in the adaptive e-learning module is easy to understand and comprehend. | 3.90 | 0.30 | Strongly Agree |
| 5. The video lesson in the adaptive e-learning module delivers information that unlocks the difficulties of the lesson. | 3.94 | 0.24 | Strongly Agree |
| Overall | 3.928 | 0.14 | Strongly Agree |

*Legend: 3.50–4.00 (Strongly Agree/Highly Acceptable); 2.50–3.49 (Agree/Acceptable); 1.50–2.49 (Disagree/Slightly Acceptable); 1.00–1.49 (Strongly Disagree/Not Acceptable).*

Table 5 illustrates the respondents' perception of using the different features of adaptive e-learning modules in terms of the video lesson. The obtained means for all the items of the e-learning module ranged from 3.84 to 3.98, verifying that the adaptive e-learning module contains video lessons that enhance learning, understanding, and comprehensionof the selected topic in physical science.

Statement 1 (The video lesson in the adaptive e-learning module is relevant to the topic) and statement 2 (The adaptive e-learning module contains a video lesson that enhances learning) strongly agree with a 3.98 mean and a standard deviation of 0.14. The findings demonstrate that adaptive e-learning module video lessons improve student engagement, motivation, and knowledge retention in e-learning modules. Videos can convey complex concepts, provide real-life examples and scenarios, and encourage participatory learning. Additionally, videos can be viewed at any time and location, allowing students to learn at their own pace and schedule. This study backs up Adewole et al. (2021) finding that video lessons are an effective educational tool for teaching physical science subjects to students. Video lessons were discovered to be more engaging than traditional lecture-based training and to improve student test performance. Video lessons' visual and aural components help students understand complex physical scientific ideas, and the ability to pause,

rewind, and re-watch video sections allows students to learn at their own pace.

Statement 3 (The adaptive e-learning module video lesson deepens my knowledge about the selected topic in physical science), which has the lowest weighted mean of 3.84 out of the five items, falls under strongly agree as qualitative description. According to the statement, video lessons can help students understand physical science concepts more deeply by visualizing complex ideas and allowing students to return information as often as necessary. The video lesson can lead to a more in-depth understanding of physical science concepts. Video lessons can improve students' learning and experience of complex physical science concepts, according to Kumar et al. (2021). These lessons' visual and auditory components can assist students in more easily grasping abstract ideas, and practical demonstrations can help them apply theoretical information to real-world scenarios. Additionally, interactive features such as quizzes and simulations can be included in video lessons to promote active learning and student engagement.

As a result, the respondents generally agree with a 3.928 mean. The findings confirm that the adaptive e-learning module's video lesson improves learning by providing students with visual and auditory experiences that aid in comprehending complex concepts.

They can introduce new ideas, review material, or reinforce learning. Additionally, the ability to pause, rewind, and re-watch video lessons provides students with an independent learning experience that allows them to learn at their own pace. The findings support the work of Luo and Qiao (2020), who demonstrated that video lessons are an effective and beneficial approach for increasing student engagement and learning outcomes in various academic areas. They can provide self-paced, interactive, and multimodal learning experiences accommodating multiple learning styles and preferences.

**Table6**. Use of the Adaptive E-learning Module in Terms of Simulation

| Indicators | M | SD | VI |
|---|---|---|---|
| 1. The simulation in the NODMA-based E-learning module helps to understand the selected topics in physical science. | 3.94 | 0.24 | Strongly Agree |
| 2. The simulation in the NODMA-based E-learning module uplifts the learning engagement level. | 3.86 | 0.35 | Strongly Agree |
| 3. The simulation in the NODMA-based eLearning module brought another innovative way of learning using technology. | 3.90 | 0.30 | Strongly Agree |
| 4. The simulation in the NODMA-based eLearning module enables one to experience the activity comprehensively. | 3.90 | 0.30 | Strongly Agree |
| 5. The NODMA-based E-learning module contains simulation that enhances learning. | 3.90 | 0.30 | Strongly Agree |
| Overall | 3.90 | 0.19 | Strongly Agree |

*Legend: 3.50–4.00 (Strongly Agree/Highly Acceptable); 2.50–3.49 (Agree/Acceptable); 1.50–2.49 (Disagree/Slightly Acceptable); 1.00–1.49 (Strongly Disagree/Not Acceptable).*

Table 6 shows the respondents' perception of using the different features of adaptive e-learning modules in simulation.The obtained means for all the items of the e-learning module ranged from 3.86 to 3.94, proving the adaptive e-learning module contains simulations that uplift the learning engagement in an innovative way of teaching and enable the learners to experience and understand the activity comprehensively.

Statement 1 (The simulation in the adaptive e-learning module helps to understand the selected topics in physical science) is rated the highest among indicators, with a mean of 3.94 and a standard deviation of 0.24 described as strongly agreeable. The indicator indicates that the simulation in the e-learning module assists learners in understanding the selected physical science topics. The simulation provides learning experiences that immerse learners in real-world scenarios and engage them in learning. This is similar to the research of Rahmatullah et al. (2021). Simulation-based learning isexcellent for teaching complex physical science concepts, particularly in improving students' problem-solving abilities and conceptual understanding. According to one study, simulation in physical science training significantly improved students' achievement and interest in the subject. Furthermore, simulation-based learning can provide students with a safe and controlled environment to experiment and

make mistakes, promoting a deeper understanding of the underlying scientific concepts.

Statement 2 (The simulation in adaptive e-learning module increases learning engagement level), with a mean of 3.84, falls under strongly agree as qualitative description. The statement concerns simulations in e-learning modules, which can increase student enthusiasm and engagement. In science education, simulations can be an effective tool for increasing student engagement and improving learning outcomes. The interactive and immersive nature of simulations can give students a sense of autonomy and control over their learning experience, leading to higher engagement and interest in the topic. This lends support to the research of Sarantakos et al. (2021). Simulations also assisted students in understanding and applying complex scientific topics and developing problem-solving and critical-thinking skills.

As a result, the respondents generally agree with a 3.90 average weighted mean. The findings confirm that simulation in adaptive e-learning modules helps understand the topic, experience the activity innovatively using technology, and improve the learning process. Furthermore, simulation exercises piqued students' interest and active participation in learning, resulting in a better understanding and learning of complex scientific topics. Simulations gave students a safe and low-risk environment to experiment and apply scientific knowledge, leading to increased confidence in their abilities. This is similar to Li et al. (2020), who found that using simulations in physical science can increase student engagement, understanding of abstract topics, and problem-solving abilities. Students can investigate and experiment with physical scientific ideas in a safe and regulated environment, creating a more participatory and immersive learning experience.

**Table7**. Acceptability of the Adaptive E-learning Module in Terms of Content Quality

| Indicators | M | SD | VI |
|---|---|---|---|
| 1. Content is consistent with topics/skills found in the DepEd Learning Competencies for the subject and grade/year level it was intended for. | 3.98 | 0.14 | Highly Acceptable |
| 2. Concepts developed to contribute to enrichment, reinforcement, or mastery of the identified learning objectives. | 3.92 | 0.27 | Highly Acceptable |
| 3. Content is accurate. | 3.94 | 0.24 | Highly Acceptable |
| 4. Content is up to date. | 3.84 | 0.37 | Highly Acceptable |
| 5. Content is logically developed and organized. | 3.74 | 0.44 | Highly Acceptable |
| 6. Content is free from cultural, gender, racial, or ethnic bias. | 3.54 | 0.50 | Highly Acceptable |
| 7. Content stimulates and promotes critical thinking. | 3.80 | 0.40 | Highly Acceptable |
| 8. Content is relevant to real-life situations. | 3.82 | 0.39 | Highly Acceptable |
| 9. Language (including vocabulary) is appropriate to the target user level. | 3.96 | 0.20 | Highly Acceptable |
| 10. Content promotes positive values that support formative growth. | 3.86 | 0.35 | Highly Acceptable |
| Overall | 3.84 | 0.12 | Highly Acceptable |

*Legend: 3.50–4.00 (Strongly Agree/Highly Acceptable); 2.50–3.49 (Agree/Acceptable); 1.50–2.49 (Disagree/Slightly Acceptable); 1.00–1.49 (Strongly Disagree/Not Acceptable).*

Table 7 reflects the acceptability of the adaptive e-learning module in terms of content quality. The obtained mean for all the items of the e-learning module ranged from 3.54 to 3.98, proving the e-learning module's acceptability. High-quality and relevant content is a crucial factor that impacts the acceptability of e-learning modules. The perceived quality of their content determines these modules'acceptability, which plays a significant role in their overall effectiveness for learners. As a result, ensuring that e-learning modules have high-quality, relevant content is essential to enhance their overall acceptability and effectiveness.

Indicator 1, which assesses if the content aligns with the DepEd Learning Competencies for the specific subject and grade level, had the highest rating with a weighted mean of 3.98 and a standard deviation of 0.14, indicating good acceptability. The indicator displays the coherence of the information in the e-learning module. Ensuring consistency in the quality and presentation of e-learning information is crucial for providing students with a great learning experience. Consistent information enhances students' understanding of the material and increases their engagement in the course. This corroborates Abdel-Salam's (2020) research. Consistency in e-learning content is crucial for facilitating learners'

understanding of the subject. Consistent content delivery helps learners anticipate and understand the course's structure and organization, resulting in improved learning outcomes.

Statement 6 (Content is free from cultural, gender, racial, or ethnic bias), the least among the five items with a mean of 3.84, falls under a highly acceptable qualitative description. The statement deals with providing an inclusive and fair learning environment in e-learning modules. There must be no cultural, gender, racial, or ethnic prejudice in the content. Bias in educational content has been demonstrated in studies to negatively influence student engagement and retention, as well as propagate harmful stereotypes and inequalities. Biased e-learning content can harm students' learning experiences from varied backgrounds and propagate stereotypes and discrimination. To encourage a more inclusive and successful learning experience for all learners, e-learning designers must critically assess and resolve any potential biases in the content. This is parallel to the work of Gadsden et al. (2021). It is essential to guarantee that the content of e-learning modules is free of cultural, gender, racial, or ethnic prejudices. This means that the subject should be delivered in a way that includes all learners, regardless of their background.

Therefore, the respondents generally evaluate highly acceptable with a 3.84 average weighted mean. Findings confirm the content quality of the adaptive e-learning module contains relevancy, correctness, and clarity of the material delivered and the appropriateness of the language and imagery utilized. All contribute to content quality. To achieve high-quality e-learning content, instructional designers must undergo a rigorous creation and review process, including subject matter experts, instructional developers, and learners. It is parallel to the study of Jing et al. (2021). The quality of e-learning content is a significant factor in student fulfillment and academic performance. Learners consider high-quality e-learning information relevant, engaging, and simple, leading to improved learning results. As a result, e-learning designers should prioritize material quality to guarantee that learners have a positive and productive learning experience.

Effective instructional design incorporating clear learning objectives, interactive elements, and appropriate feedback can increase e-learning module quality and student performance. Table 8 in the succeeding page shows the acceptability of the adaptive eLearning module in terms of instructional quality. The obtained weighted mean for all the items of the e-learning module ranged from 3.82 to 3.98, which proved the instructional quality of e-learning modules is vital to student engagement, learning results, and overall course satisfaction.

Among indicators, statement 2 (Material achieves its defined purpose) and statement 8 (Feedback on target user's responses is effectively employed) are rated highest with a 3.98 weighted mean and standard deviation of 0.14 described as highly acceptable.

**Table8**. Acceptability of the Adaptive E-learning Module in Terms of Instructional Quality

| Indicators | M | SD | VI |
|---|---|---|---|
| 1. The purpose of the material is well-defined. | 3.92 | 0.27 | Highly Acceptable |
| 2. Material achieves its defined purpose. | 3.98 | 0.14 | Highly Acceptable |
| 3. Learning objectives are clearly stated and measurable. | 3.90 | 0.30 | Highly Acceptable |
| 4. The level of difficulty is appropriate for the intended target user. | 3.90 | 0.30 | Highly Acceptable |
| 5. Graphics/colors/sounds are used for appropriate instructional reasons. | 3.82 | 0.39 | Highly Acceptable |
| 6. Material is enjoyable, stimulating, challenging, and engaging. | 3.88 | 0.33 | Highly Acceptable |
| 7. Material effectively stimulates the creativity of the target user. | 3.86 | 0.35 | Highly Acceptable |
| 8. Feedback on the target user's responses is effectively employed. | 3.98 | 0.14 | Highly Acceptable |
| 9. Target users can control the presentation and review rate and sequence. | 3.92 | 0.27 | Highly Acceptable |
| 10. Instruction is integrated with the target user's previous experience. | 3.92 | 0.27 | Highly Acceptable |
| Overall | 3.908 | 0.12 | Highly Acceptable |

*Legend: 3.50–4.00 (Strongly Agree/Highly Acceptable); 2.50–3.49 (Agree/Acceptable); 1.50–2.49 (Disagree/Slightly Acceptable); 1.00–1.49 (Strongly Disagree/Not Acceptable).*

Table 8 presents the perceived acceptability of the adaptive e-learning module regarding instructional quality. The result proves that the adaptive e-learning module states the purpose that achieves the goal. Adaptive e-learning resources that promote learning by aligning with the targeted

learning outcomes and ensuring the content is arranged and presented clearly and logically.

Adding interactive components, such as quizzes and simulations, can increase the instructional quality of e-learning materials and increase learners' engagement and satisfaction with the content. This supports the study of Abdous et al. (2018). Instructional resources in e-learning modules that met their objectives had a considerably favorable impact on student learning outcomes. Furthermore, feedback on target users' responses was discovered to be an effective instructional method that enhanced learning results. This emphasizes the significance of creating functional e-learning materials with appropriate feedback mechanisms to support student learning. Therefore, the respondents generally evaluate highly acceptable with a 3.908 average weighted mean. Findings confirm the instructional quality of the adaptive eLearning module is appropriate for the learner. It gives proper instruction and well-defined and measurable objectives, stimulates creativity, and the feedback is appropriately employed. High-quality instructional e-learning modules can facilitate effective learning and increase learner engagement. This is parallel to the work of Lee et al. (2020), who found that the instructional quality of e-learning modules substantially impacts learners' academic achievement and course satisfaction. This includes several important variables contributing to instructional quality, such as well-designed learning objectives, interactive multimedia, and suitable feedback methods. Furthermore, the study emphasized the significance of clear and straightforward instructions and the alignment of evaluations with learning outcomesdescribed as highly acceptable.

**Table9**. Acceptability of the Adaptive E-learning Module in Terms of Instructional Quality

| Indicators | M | SD | VI |
|---|---|---|---|
| 1. Audio enhances understanding of the concept. | 3.94 | 0.24 | Highly Acceptable |
| 2. Speech and narration (correct pacing, intonation, and pronunciation) are clear and easily understood. | 3.78 | 0.42 | Highly Acceptable |
| 3. There is complete synchronization of audio with the visuals. | 3.82 | 0.39 | Highly Acceptable |
| 4. Music and sound effects are appropriate and effective for instructional purposes. | 3.84 | 0.37 | Highly Acceptable |
| 5. Screen displays (text) are uncluttered, easy to read, and aesthetically pleasing. | 3.74 | 0.44 | Highly Acceptable |
| 6. Visual presentations (non-text) are clear and easy to interpret. | 3.70 | 0.46 | Highly Acceptable |
| 7. Visuals sustain interest and do not distract the user's attention. | 3.64 | 0.48 | Highly Acceptable |
| 8. Visuals provide an accurate representation of the concept discussed. | 3.82 | 0.39 | Highly Acceptable |
| 9. The design allows the target user to navigate freely through the material. | 3.74 | 0.44 | Highly Acceptable |
| 10. The material can quickly and independently be used. | 3.90 | 0.30 | Highly Acceptable |
| Overall | 3.792 | 0.16 | Highly Acceptable |

*Legend: 3.50–4.00 (Strongly Agree/Highly Acceptable); 2.50–3.49 (Agree/Acceptable); 1.50–2.49 (Disagree/Slightly Acceptable); 1.00–1.49 (Strongly Disagree/Not Acceptable).*

Table 9 on the succeeding page shows the acceptability of the adaptive e-learning module in terms of technical quality. The obtained weighted mean for all the items of the e-learning module ranged from 3.64 to 3.94, proving the technical quality of adaptive eLearning is an essential aspect of their overall efficacy and success. The usability, accessibility, and dependability of the e-learning platform and tools are termed technical quality. To ensure a favorable learning experience for users and participants in the learning process, e-learning modules must prioritize technological innovation. Among indicators, statement 1 (Audio enhances understanding of the concept) is rated highest with a 3.94 mean and standard deviation of 0.24, described as highly acceptable.

The result proves that audio narration in e-learning modules can dramatically boost students' knowledge and recall of course materials. The audio narration can assist students in processing knowledge more efficiently and effectively and increase their interest in the material. As a result, including audio narration in e-learning modules can be an effective technique for increasing these modules' technical quality. This supports the study of Tuovinen et al., (2019) that audio in e-learning modules can help students better understand the concepts being taught. Audio can help improve

the technical quality of e-learning courses and learners' understanding and recall of complicated subjects (Siudad & Aliazas, 2022).

Statement 7 (Visuals maintain interest and do not distract the user's attention), with a weighted mean of 3.64, falls under highly acceptable as a qualitative description. The statement refers to the visual presentation in the adaptive e-learning module, which aids students' learning and prevents learners from becoming distracted by the e-learning module's graphic representation. Visuals in e-learning courses should be appealing and maintain user interest and not divert attention away from the learning content, according to Jahan et al. (2021). Excessive or irrelevant graphics can impede learning and make the module appear amateurish. As a result, creating images consistent with the learning objectives while engaging learners without overloading them is critical.

As a result, the respondents rate it highly acceptable, with a 3.792 average weighted mean. The findings confirm that the technical quality of the adaptive e-learning module is appropriate for the learner, providing an e-learning module that sustains interest and improves the learners' ability to understand the concept in physical science. Learners' perceptions of the technical quality of e-learning modules significantly impact their overall satisfaction and future interest in using the system. Learners place a high value on the dependability, ease of use, and accessibility of e-learning platforms, and technical issues can significantly reduce learners' perceived value of the system. Overall, providing excellent technical quality is critical for the acceptability and success of e-learning systems. The findings support Li et al.'s (2018) study, which found that learners viewed e-learning materials designed with excellent technical quality favorably, resulting in increased engagement and satisfaction with the course. The ease of use, accessibility, and usefulness of e-learning modules are critical factors in determining their overall acceptance in terms of technical quality. Furthermore, the effective use of multimedia features like visuals and interactive components improved the technical quality and acceptability of e-learning materials.

**Table10**. Pre-test and post-test results in Student's Level of Critical Thinking in Terms of Applying, Analyzing, Evaluating and Creating

| | PRE-TEST | | POST-TEST | |
|---|---|---|---|---|
| Applying | f | % | f | % |
| 0 to 3 | 45 | 90 | 0 | 0 |
| 4 to 6 | 5 | 10 | 0 | 0 |
| 7 to 10 | 0 | 0 | 50 | 100 |
| Total | 50 | 100 | 50 | 100 |
| Analyzing | | | | |
| 0 to 3 | 47 | 94 | 0 | 0 |
| 4 to 6 | 3 | 6 | 0 | 0 |
| 7 to 10 | 0 | 0 | 50 | 100 |
| Total | 50 | 100 | 50 | 100 |
| Evaluating | | | | |
| 0 to 3 | 39 | 78 | 0 | 0 |
| 4 to 6 | 11 | 22 | 0 | 0 |
| 7 to 10 | 0 | 0 | 50 | 100 |
| Total | 50 | 100 | 50 | 100 |
| Creating | | | | |
| 0 to 3 | 45 | 90 | 0 | 0 |
| 4 to 6 | 5 | 10 | 0 | 0 |
| 7 to 10 | 0 | 0 | 50 | 100 |
| Total | 50 | 100 | 50 | 100 |

Table 10 shows students' critical thinking levels in applying, analyzing, evaluating and creating.In applying, the obtained pre-test frequency of the students with a score of 0 to 3 is 45, with a percentage of 90%. There 10% of the students scored 4 to 6 with a frequency of 5, and 0% got a score of 7 to 10. The obtained post-test frequency of the students applying with the score of 7 to 10 is 50, with a percentage of 100%. However, in analyzing the received pre-test frequency of the students with the score of 0 to 3 is 47 with a percentage of 94%. There are 6% of the students with a score of 4 to 6 with a frequency of 5 and 0% of the students got a score of 7 to 10. The obtained post-test frequency of the students in analyzing with the score of 7 to 10 is 50 with a percentage of 100%. This shows that the learners develop analyzing skills after using the adaptive e-learning module. The result illustrates that an adaptive e-learning module enhances the applying abilities of the learners.

Furthermore, in evaluating the obtained pre-test frequency of the students with a score of 0 to 3, it is 39 with a percentage of 78%. There, 22% of the students scored 4 to 6 with a frequency of 11, and 0% got a 7 to 10. The obtained post-test frequency of the students in analyzing with the score of 7 to 10 is 50 with a percentage of 100%. The results of the pre-test and the post-test in evaluating show the excellent effect of the adaptive eLearning module in analyzing the concepts in physical science. In creating, the pre-test frequency of the students with the score of 0 to 3 is 45, with a percentage of 90%. There, 10% of the students got a score of 4 to 6 with a frequency of 10, and 0% got a 7 to 10. The obtained post-test frequency of the students in creating with the score of 7 to 10 is 50 with a percentage of 100%. The result shows that the adaptive e-learning module develops the learners' critical thinking skills to create.

This is parallel to the work of Sivan et al. (2021). It was discovered that using e-learning modules was an excellent

technique for improving students' problem-solving skills in Physical Science. The modules included interactive simulations and visual representations of complicated concepts, which assisted students in better understanding and using problem-solving strategies. Students expressed strong interest in the modules meant to be both demanding and rewarding. Overall, e-learning modules have the potential to improve problem-solving abilities and increase participation in Physical Science education.

**Table11**. Level of Student Engagement in Physical Science in terms of motivation

| Indicators | M | SD | VI |
|---|---|---|---|
| 1. Adaptive e-learning module develops the motivation to learn. | 4.00 | 0.00 | Strongly Agree |
| 2. Adaptive e-learning module addresses facilitating conditions towards learning. | 4.00 | 0.00 | Strongly Agree |
| 3. Adaptive e-learning modules inhibit attention toward learning. | 4.00 | 0.00 | Strongly Agree |
| 4. It results in active participation in teaching and learning. | 3.94 | 0.24 | Strongly Agree |
| 5. Adaptive e-learning module develops an interest in the learning process. | 3.92 | 0.27 | Strongly Agree |
| Overall | 3.972 | 0.09 | Strongly Agree |

*Legend: 3.50–4.00 (Strongly Agree/Highly Acceptable); 2.50–3.49 (Agree/Acceptable); 1.50–2.49 (Disagree/Slightly Acceptable); 1.00–1.49 (Strongly Disagree/Not Acceptable).*

Table 11 demonstrates the respondent's assessment of students' engagement level with the adaptive e-learning module in Physical Science based on motivation.

The weighted mean of all items in the e-learning module's motivation ranged from 3.92 to 4.00, confirming that the adaptive e-learning module effectively encourages students during the learning process. Moreover, motivation is crucial in influencing student engagement in e-learning by inspiring students to start and sustain their learning endeavors. When motivated, students are more inclined to participate in e-learning activities and assume responsibility for their learning.

The findings show that student's motivation to learn significantly impacted their engagement with e-learning modules. Statement 1 (Adaptive e-learning module develops motivation to learn), Statement 2 (Adaptive e-learning module addresses facilitating conditions towards learning), and Statement 3 (Adaptive e-learning module inhibits attention towards learning) are rated as strongly agree with a 4.00 weighted mean. By increasing motivation to learn and developing a study habit for education, the adaptive eLearning module assists learners in developing unique ways of learning. This is similar to Meng's research (2021). E-learning modules can include interactive elements like gamification and social learning, which can increase study motivation by encouraging engagement, enjoyment, and a sense of accomplishment.
Statement 5 (Adaptive e-learning module fosters an interest in the learning process), with a weighted mean of 3.92, falls under strongly agree as a qualitative description. The statement refers to the growth of interest in learning using the adaptive e-learning module. E-learning modules can enhance students' learning experiences and foster a lifelong love of learning. Using e-learning modules can increase motivation to learn by allowing learners to learn at their own pace and by incorporating multimedia elements that increase the relevance and applicability of the learning material. This supports Alzahrani's research (2021) The flexibility of e-learning modules allows students to learn at their own pace and in their own time, fostering a sense of autonomy. This can lead to better knowledge retention and comprehension, which increases motivation and interest in learning.

Therefore, the respondents strongly agree with a 3.972 average weighted mean.

Findings confirm that motivation enhances the student's learning and enhances the capacity to participate in the learning process. The adaptive e-learning module creates an environment for students to promote a quality learning process. This parallels the study of Ertmer (2020). Motivation is a significant component influencing student involvement in e-learning. Students are more likely to actively participate in learning, such as asking questions and completing tasks when driven to learn. This participation assists them in developing a deeper comprehension of the content, resulting in improved learning outcomes.

**Table12**. Level of Student Engagement in Physical Science in Terms of Participation in Learning

| Indicators | M | SD | VI |
|---|---|---|---|
| 1. The adaptive e-learning module helps to engage more in learning. | 3.96 | 0.20 | Strongly Agree |
| 2. The adaptive e-learning module helps increase comprehension levels when solving word problems in physics. | 3.94 | 0.24 | Strongly Agree |
| 3. The adaptive e-learning module helps students learn new ideas in physical science. | 3.92 | 0.27 | Strongly Agree |
| 4. learning concepts in physical science become more understandable with adaptive e-learning modules. | 3.88 | 0.33 | Strongly Agree |
| 5. The adaptive e-learning module helps support the process of engagement in learning. | 3.94 | 0.24 | Strongly Agree |
| Overall | 3.928 | 0.16 | Strongly Agree |

*Legend: 3.50–4.00 (Strongly Agree/Highly Acceptable); 2.50–3.49 (Agree/Acceptable); 1.50–2.49 (Disagree/Slightly Acceptable); 1.00–1.49 (Strongly Disagree/Not Acceptable).*

The adaptive e-learning module allows students to participate in their learning process through interactive and immersive experiences that can boost motivation and promote active learning. Table 12 on the succeeding page shows the respondent's evaluation of students' engagement in using the adaptive e-learning module in Physical Science in terms of participation in learning. The obtained weighted mean for all the items in the access of the e-learning module ranged from 3.88 to 3.96, showing the adaptive learning module engages the learners in the learning process to improve comprehension and understanding in problem-solving.

Among indicators, statement 1 (The adaptive e-learning module helps to engage more in learning) is rated highest with a 3.96 weighted mean and standard deviation of 0.20 described as strongly agree. The findings indicate that the adaptive e-learning module aids in learners' engagement in the learning process by allowing students to actively participate in the learning process and communicate with course material, peers, and instructors. E-increased learning involvement can improve students' academic performance and learning outcomes.

This lends support to the research of Kuo et al. (2021). By providing interactive features that allow students to participate actively in the learning process, e-learning has been shown to increase student engagement. Students interacting with the course material are more likely to retain knowledge and improve their understanding of the subject matter. With a mean of 3.88, Statement 4 (The learning of concepts in physical science becomes more understandable using the adaptive e-learning module) falls under strongly agree as a qualitative description. Because they encourage student engagement and active participation, adaptive e-learning modules effectively teach physics concepts to high school students. The interactive and visual nature of e-learning modules improves understanding of abstract concepts such as those found in physical science, resulting in more effective learning outcomes. According to Jennum et al. (2020), e-learning modules improved students' understanding and involvement in learning physical science concepts. Students could explore and manipulate abstract concepts more concretely and relevantly because of interactive features such as simulations, animations, and videos.

As a result, the respondents generally agree with a 3.928 average weighted mean. The findings confirm that adaptive e-learning modules increase learners' engagement in learning and are a useful innovative tool in providing support to increase the level of comprehension in a specific topic in physics. This is similar to Liang's (2020) study, which found that incorporating interactive features in e-learning modules can increase student engagement and motivation in Physical Science classes. Especially with interactive elements incorporated into the design, E-learning modules can effectively improve student engagement and learning outcomes in Physical Science courses.

**Table13**. Level of Student Engagement in Terms of Meaningful Communication

| Indicators | M | SD | VI |
|---|---|---|---|
| 1. Adaptive e-learning module creates a virtual classroom to make communication possible. | 4.00 | 0.00 | Strongly Agree |
| 2. Technology improved the social development of the learners. | 3.96 | 0.20 | Strongly Agree |
| 3. The adaptive e-learning module helps to express ideas. | 3.94 | 0.24 | Strongly Agree |
| 4. The adaptive e- | 3.94 | 0.24 | Strongly |

| | | | |
|---|---|---|---|
| learning module is a tool that innovates how lessons are delivered. | | | Agree |
| 5. It makes the understanding more comprehensive and initiates meaningful communication. | 3.96 | 0.20 | Strongly Agree |
| Overall | 3.96 | 0.09 | Strongly Agree |

*Legend: 3.50–4.00 (Strongly Agree/Highly Acceptable); 2.50–3.49 (Agree/Acceptable); 1.50–2.49 (Disagree/Slightly Acceptable); 1.00–1.49 (Strongly Disagree/Not Acceptable).*

Table 13 on the succeeding page reflects the respondent's evaluation of students' engagement in using the adaptive e-learning module in Physical Science in terms of meaningful communication in learning. The obtained mean for all the items in the eLearning module ranged from 3.94 to 4.00, proving that the adaptive e-learning module creates meaningful communication for the learners and improves social and technological aspects in delivering the lessons.
Among indicators, statement 1 (Adaptive e-learning module creates a virtual classroom to make communication possible) is rated highest with a 4.00 weighted mean described as strongly agree. The result shows that the adaptive e-learning module creates an innovative classroom that communicates to learners to engage in meaningful learning.

Communication was necessary for improving student participation in e-learning modules. Effective communication in virtual classrooms, in particular, enabled information exchange, feedback, and social contact, resulting in higher student engagement and motivation in the learning process.
Incorporating communication and collaboration options into online learning modules can improve student engagement, motivation, and learning results in Physical Science. This supports the study of Xiong et al. (2020) that learners liked the opportunity to communicate and collaborate meaningfully with peers, instructors, and course content in online learning environments and e-learning modules. Furthermore, meaningful communication and collaboration behaviors demonstrate an understanding of the importance of establishing effective creative e-learning environments.

Statement 3 (The adaptive e-learning module helps to express ideas) and statement 4 (An adaptive e-learning module is a tool that innovates the way of delivering lessons), the least among the five items with a weighted mean of 3.94, falls under strongly agree as a qualitative description. The statement illustrates that adaptive e-learning modules innovate the way of delivering the lesson and help the learners express their ideas in a particular lesson. Moreover, e-learning modules using digital media resources can encourage active learning and a better grasp of Physical Science ideas. This is parallel to the study of Joo et al. (2019); e-learning modules that include digital media technologies, such as virtual simulations and multimedia presentations, can improve students' ability to express themselves and revolutionize Physical Science lessons. E-learning modules that use digital media tools can encourage active learning and build a deeper understanding of Physical Science.

Therefore, the respondents strongly agree with a 3.96 average weighted mean. Findings confirm that adaptive e-learning modules enable students to express their views and reinvent how courses are delivered. This results in a more dynamic and collaborative learning experience where students may engage in meaningful debates and share their knowledge with their classmates. Interactive e-learning modules, such as educational modules, video lessons, and simulations, can increase student engagement and help them convey their ideas more effectively in Physical Science courses. When utilized, positive attitudes toward learning and the e-learning models can help students engage in e-learning modules. This supports the study of Rahmawati et al. (2020).

**Table14**. Level of Student Engagement in terms of Problem-Solving

| Indicators | M | SD | VI |
|---|---|---|---|
| 1. The adaptive e-learning module helps present diagrams and figures that are always required to support the answer in problem-solving. | 3.98 | 0.14 | Strongly Agree |
| 2. The adaptive e-learning module provides concepts required to create logical and critical thinking in answering word problems in physics. | 3.88 | 0.33 | Strongly Agree |
| 3. There is a sufficient application to explain comprehensively the problem solving. | 3.88 | 0.33 | Strongly Agree |
| 4. Adaptive e-learning module creates an innovative classroom to perform problem-solving. | 3.88 | 0.33 | Strongly Agree |
| 5. The adaptive e- | 3.94 | 0.24 | Strongly |

| | | | |
|---|---|---|---|
| learning module supports the application of theories and concepts in problem-solving. | | | Agree |
| Overall | 3.912 | 0.14 | Strongly Agree |

*Legend: 3.50–4.00 (Strongly Agree/Highly Acceptable); 2.50–3.49 (Agree/Acceptable); 1.50–2.49 (Disagree/Slightly Acceptable); 1.00–1.49 (Strongly Disagree/Not Acceptable).*

E-learning modules that include interactive features such as simulations and animations engage students in problem-solving activities and improve students' participation in problem-solving. Table 14 reflects the respondent's evaluation of students' engagement in problem-solving using the adaptive e-learning module in Physical Science. The obtained weighted mean for all the items in the access of the eLearning module ranged from 3.88 to 3.98, verifying that the adaptive e-learning module can be a useful tool for enhancing problem-solving abilities in Physical Science.

Among indicators, statement 1 (The adaptive e-learning module helps to present diagrams and figures that are always required to support the answer in problem-solving) is rated highest with a 3.98 weighted mean and standard deviation of 0.14 described as strongly agree. The result shows that the adaptive e-learning module contains diagrams and illustrations that support a better understanding of the physical science concept and problem-solving. E-learning modules have been found to enhance student engagement in physical science. This is partly due to e-learning modules' capacity to display diagrams and figures, which are always needed to support the solution in problem-solving. This parallels the study of Nourbakhsh et al. (2020). Illustrations such as diagrams and figures, which are always required to support the answer in problem-solving exercises in Physical Science courses, can be provided by e-learning modules. Using e-learning modules featuring diagrams and figures improved students' physical science achievement, particularly for those with visual and kinesthetic learning styles.

Statement 2 (The adaptive e-learning module provides concepts required to create logical and critical thinking in answering word problems in physics), statement 3 (There is a sufficient application to explain comprehensively the problem solving) and statement 4 (adaptive e-learning module creates an innovative classroom to perform problem-solving) which is the least among the five items with a weighted mean of 3.88, falls under strongly agree as a qualitative description. The statement explains that adaptive e-learning modules provide concepts needed to develop logical and critical thinking when answering physics word problems. Contains enough application to explain and establish an innovative classroom for problem-solving fully. This supports the study of Elbanouby et al. (2021), who found thateLearning modules can help students engage and succeed in problem-solving tasks in physical science classes. The interactive aspects included in the e-learning modules, such as simulations and virtual experiments, were incredibly beneficial in engaging students and boosting their grasp of the problem-solving process. Therefore, the respondents strongly agree with a 3.912 average weighted mean.

Findings confirm that adaptive e-learning modules enable students to aid in the development of a more inclusive classroom environment. This is because e-learning modules may be accessible to students with various learning styles and skills. E-learning modules can be a helpful tool for enhancing student engagement and creating an innovative classroom environment in which to solve physical science problems. The e-learning modules can help students learn more efficiently and retain information by giving them access to interactive content, individualized learning, and rapid feedback. E-learning modules can effectively improve student engagement, foster an innovative classroom environment, and make science education more inclusive. This illustrates the work of Huang (2017). It was discovered that using e-learning modules was an excellent technique for improving students' problem-solving skills in Physical Science. The modules included interactive simulations and visual representations of complicated concepts, which assisted students in better understanding and using problem-solving strategies. Students expressed strong interest in the modules meant to be both challenging and rewarding. Overall, eLearning modules have the potential to improve problem-solving abilities and increase participation in Physical Science education.

**Table15**. Significant Difference Between Pre-test and Post-test on Students' Level of Critical Thinking

| Critical Thinking Skills | MD | t | Sig |
|---|---|---|---|
| Applying | 7.26 | 51.014 | .000 |
| Analyzing | 7.18 | 55.247 | .000 |
| Evaluating | 6.68 | 35.072 | .000 |
| Creating | 7.1 | 41.855 | .000 |
| Overall | 28.22 | 77.294 | .000 |

*Legend: If p-value Sig. (2-tailed) $\leq 05$, then it is statistically significant. Df =49*

Table 15 compares pre-test and post-test scores, showing students' critical thinking skills development. The average score before the test is 9.56, with a standard deviation of 2.37. The post-test shows a significant improvement, with an average score of 37.78 and a standard deviation of 1.25.

The significant change is highlighted by the calculated t-value of -77.294 at a significance level of 0.05, indicating a statistically significant difference between the pre-test and post-test outcomes.

The enhancement noticed is due to the introduction of an adaptive e-learning module, which has been effective in developing critical thinking skills in learners. This increase is particularly noticeable in different aspects of critical thinking, including applying, analyzing, evaluating, and creating information.

The results support the claims made by Arslan (2019), whose study highlights the effectiveness of e-learning modules, especially those containing interactive elements like simulations, animations, and videos. These features support inquiry-based learning and enable students to apply their knowledge to real-world situations in the field of scientific education.

The study demonstrates how adaptive e-learning methods significantly enhance students' critical thinking skills, enriching their educational experiences and preparing them for the challenges of the modern world.

**Table16**. Relationship Between Student Level of Engagement and Using the Adaptive E-learning Module.

| | Students' Level of Engagement in using the Adaptive E-learning Module | | | |
|---|---|---|---|---|
| | M | EIL | MC | PS |
| Access | .948** | - | - | - |
| Resources | - | .801** | .757** | .684** |
| Technical Support | .957** | - | - | .310** |
| Interactive eLearning Module | .623** | .391** | .256** | .545** |
| Video Lesson | - | .467** | .448** | - |
| Simulation | .239** | .344** | .738** | - |
| Content Quality | .577** | .374** | - | - |
| Instructional Quality | .360** | .816** | .311** | .522** |
| Technical Quality | - | .206** | .669** | - |

*Legend: ** correlation is significant at. 0.01 level; * correlation is significant at 0.05 level.*

Table 16 displays the correlation test between the adaptive e-learning module and the level of student engagement in Physical Science. The investigation found a substantial relationship between motivation and access, technical support, interactive e-learning modules, simulation, content quality, and instructional quality. The study indicates that the created e-learning module boosts students' involvement in physical science by increasing their motivation. Motivation is crucial for engaging e-learning students, encouraging them to initiate and sustain learning tasks. Students are more inclined to participate in e-learning activities and assume accountability for their learning when motivated.

Engagement in learning allows students to participate in their learning through interactive and immersive experiences that can increase engagement and promote active learning. On the other hand, resources, interactive e-learning modules, video lessons, simulation, content quality, instructional quality and technical quality have a significant relationship with engagement in learning. This illustrates that the developed e-learning module enhances the students' engagement in learning.

Furthermore, resources, interactive e-learning modules, video lessons, simulation, and technical quality all strongly relate to meaningful communication. This demonstrates that the developed e-learning module improved students' meaningful communication. Students can use adaptive e-learning modules to express their opinions and reimagine how courses are presented. This results in a more dynamic and collaborative learning experience where students can engage in relevant debates and share their knowledge with their classmates.

Furthermore, problem-solving is strongly related to resources, technical support, interactive e-learning modules, and instructional quality. The outcome demonstrates how the adaptive e-learning module improved problem-solving skills. E-learning modules with interactive features, such as simulations and animations, engage students in problem-solving activities and increase their participation. According to Arslan (2019), interactive features in e-learning modules such as simulations, animations, and videos can improve students' critical thinking skills in science education by encouraging inquiry-based learning and allowing students to apply their knowledge to real-world scenarios.

## IV. CONCLUSION

The analysis shows a significant difference in students' critical thinking skills before and after using the adaptive e-learning module. The difference highlights the significant improvement in critical thinking skills after the educational intervention was carried out. The observed change shows the effectiveness of the adaptive e-learning method and

emphasizes its ability to stimulate cognitive growth and intellectual development in pupils.

The results indicate a strong relationship between the advanced adaptive e-learning module and students' participation in Physical Science. This association explains how pedagogical innovation and academic involvement are interdependent, highlighting how the interactive and dynamic e-learning platform enhances student interest and participation in the subject matter.

The adaptive e-learning module improves students' critical thinking abilities and fosters a more engaging learning environment, leading to a deeper connection and enthusiasm for Physical Science. Aligning instructional methods with student engagement shows a promising way to improve educational outcomes and create a more enjoyable learning experience for students in Physical Science.

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