INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND ANALYSIS

ISSN(print): 2643-9840, ISSN(online): 2643-9875

Volume 08 Issue 02 February 2025

DOI: 10.47191/ijmra/v8-i02-09, Impact Factor: 8.266

Page No. 492-505

Development of Pre-Calculus Electronic Instructional Module (PEIM) Based on Least Mastered Competencies

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ABSTRACT: This study aimed to develop and validate Pre-Calculus Electronic Instructional Module (PEIM) that is intended to innovate instruction and encourage learner engagement at the senior high school level. This descriptive developmental research used the ADDIE model which involved five phases: Phase I-Analysis; Phase II-Design; Phase III-Development; Phase IV-Implementation; and Phase V-Evaluation. During the initial phase of the study, the least mastered competencies in Pre-Calculus were identified and became the basis for the development of the material. It also revealed that students encountered challenges in learning independently, receiving limited teacher support, feedback delay, lack interactive elements of module, lack of motivation and limited access to resources. Thus, the PEIM is designed to be published online and available offline to ease access during remote learning setups and for learners using electronic devices such as smartphones, tablets, laptops, or personal computers with the help of Kotobee Reader. It features innovative and interactive elements including the following: AI text-to-speech, video lessons, graphics, animations, and interactive activities. Students and expert validators were purposefully selected to evaluate the developed e-module. The PEIM attained "Passed" ratings on content, instructional, and technical qualities. Pre-calculus teachers, mathematics experts, and students evaluated the PEIM as "Very Satisfactory." The study further revealed that students performed better in Pre-Calculus after the implementation of the PEIM. The designed electronic modules are acceptable, recommended, and enhance achievements while providing a positive learning experience for students. Thus, PEIMs are recommended to be reproduced and implemented as one of the learning resources in Pre-Calculus for SHS students.

KEYWORDS: Electronic Instructional Module, Online Distance Learning, Least Mastered Competencies, Pre-Calculus, Senior High School

I. INTRODUCTION

The importance of mathematics is globally recognized, essential across fields like science, engineering, IT, and business. Mathematics extends beyond calculations—it enables understanding of structures, relationships, and patterns, fostering critical thinking and creativity essential for innovation (MAA, 2022). The MAA highlights how mathematics systematically trains individuals to develop impactful solutions in our data-driven world.

Despite its academic significance, Filipino students consistently perform poorly in math, as evidenced by international assessments like TIMSS 2019 and PISA 2018 and 2022. TIMSS 2019 results ranked Filipino elementary students last in Mathematics and Science among 57 countries, while PISA 2018 and 2022 showed scores in Mathematics below international averages (Mullis et al., 2020; OECD, 2023). Similarly, the 2019 Basic Education Exit Assessment (BEEA) revealed that most public high school students scored below the 75% criterion, a trend persisting for years (DepEd, 2019).

Efforts to improve math education have been hindered by challenges like the COVID-19 pandemic. When face-to-face classes were suspended, the Philippines adopted modular distance learning as the preferred modality (Tria, 2020; Bernardo, 2020). However, studies (Bringula et al., 2019; Dangle, 2021) noted the pandemic exacerbated the difficulty of teaching mathematics, with students often disengaged by plain, non-interactive modules.

The discussion regarding the gaps in mathematics education in the Philippines is supported by various studies and international assessments. These highlight a significant gap, as students consistently perform below global standards despite the recognized importance of mathematics across various fields. This study aims to bridge this gap by developing an electronic instructional module that integrates Information and Communications Technology (ICT) to enhance student engagement and improve learning outcomes in mathematics.

This study addresses gaps in math education by developing and evaluating an electronic instructional module (e-module) integrating ICT. Unlike traditional printed modules, e-modules feature videos, audios, and animations to promote active learning. Vianis et al. (2022) emphasized the benefits of transitioning to e-modules, as they enhance student engagement, motivation, and accessibility, all critical for academic success.

II. STATEMENT OF THE PROBLEM

This study aimed to develop and validate Pre-Calculus Electronic Instructional Module (PEIM) based on the least mastered competencies for Senior High School students. Specifically, this study intended to answer the following questions:

1. What are the challenges encountered by the Senior High School students in the implementation of Modular Distance Learning in Pre-Calculus?
2. What are the least mastered competencies of Senior High School students in Pre-Calculus?
3. What Pre-Calculus Electronic Instructional Module (PEIM) can be developed to cater to the least mastered competencies of Senior High School students in Pre-Calculus?
4. What is the evaluation rating of the developed Pre-Calculus Electronic Instructional Module by the experts in terms of:
    4.1. Content quality;
    4.2. Instructional quality;
    4.3. Technical quality; and
    4.4. Other findings?
5. Is there a significant difference in the mathematics achievement of the students before and after the implementation of the developed Pre-Calculus Electronic Instructional Module?
6. What is the evaluation rating of the educational qualities of the Pre-calculus Electronic Instructional Module by the students, and experts in terms of:
    6.1 Integrity;
    6.1 Learner Focus;
    6.3 Usability; and
    6.4 Accessibility?
7. What are the Senior High School students' experiences on the developed Pre-Calculus Electronic Instructional Module?

III. METHODS

This study employed a descriptive developmental research approach to establish an empirical basis for developing the Pre-Calculus Electronic Instructional Module (PEIM). Specifically, the researcher utilized the ADDIE Model, which consists of five phases: Phase I - Analysis, Phase II - Design, Phase III - Development, Phase IV - Implementation, and Phase V - Evaluation.

The study involved three groups of respondents. The first group consisted of 148 Grade 12 Science, Technology, Engineering, and Mathematics (STEM) students from Muntinlupa National High School during the 2021–2022 school year. The number of respondents was determined using the Raosoft sample size calculator, with a 5% margin of error. These students had already completed the Pre-Calculus subject. They were selected using convenience sampling. These students were given an achievement test to determine the least mastered competencies in Pre-Calculus. Additionally, 10 randomly selected students were included in an interview to determine the challenges they encountered throughout the implementation of Modular Distance Learning in Pre-Calculus.

The second group consisted of 10 expert validators, as recommended by Reeves and Yamashita (2021), to ensure comprehensive feedback on both content and pedagogical approaches. These experts included four Pre-Calculus teachers and six mathematics specialists chosen through purposive sampling. They evaluated the PEIM based on content quality, instructional quality, technical quality, other findings, and educational soundness.

The third group of respondents was the 80 grade 11 STEM students who served as the participants in the tryout of the developed PEIM. These students were enrolled in Pre-Calculus during the school year 2021-2022. The students with available gadgets were purposefully selected by the researcher. They evaluated the effectiveness of PEIM using the Educational Soundness General Evaluation Checklist, Pretest, and Posttest in Pre-Calculus. Moreover, 10 randomly selected students were included in a one-on-one interview to document their learning experiences in using PEIM. The study was conducted during the school year 2021 – 2022.

A. Instrumentation and Validation

In this study, data were collected using six instruments:

1. Evaluation Rating Sheet for Non-Print Materials: Adapted from the Department of Education (DepEd) Learning Resources Management and Development System (LRMDS), this standardized tool assessed the quality of the Pre-Calculus Electronic Instructional Modules (PEIM). It consisted of 37 items divided into four evaluation criteria: content quality, instructional quality, technical quality, and other findings (errors).
2. Educational Soundness General Evaluation Checklist: Also adapted from DepEd's LRMDS, this instrument evaluated the educational qualities of the PEIM across four criteria: integrity, learner focus, usability, and accessibility. It consisted of 22 items rated on a 4-point Likert scale (4 - very satisfactory, 3 - satisfactory, 2 - poor, and 1 - not satisfactory). This checklist was face- and content-validated by three experts.
3. Achievement Test in Pre-Calculus: A 35-item test, aligned with the Pre-Calculus Most Essential Learning Competencies (MELCs), identified students' least mastered competencies. The test's reliability was confirmed with a Cronbach's Alpha value of 0.84, indicating high reliability.
4. Pretest and Posttest in Pre-Calculus: The pretest gathered baseline information about students' knowledge before using the PEIM, while the posttest measured their learning gains after exposure to the module. Both tests were face- and content-validated by three mathematics experts, with a Cronbach's Alpha value of 0.80, indicating high reliability.
5. Interview Guide on Challenges in Modular Distance Learning in Pre-Calculus: This semi-structured guide included questions about the challenges students faced during Modular Distance Learning in Pre-Calculus. One-on-one interviews were conducted with selected students.
6. Interview Guide on Student Experiences with PEIM: This open-ended instrument explored students' experiences with the PEIM after using it. It contained 10 questions focused on their perceptions of the module's features, video lessons, accessibility, technical aspects, interactivity, and overall effectiveness. This guide was validated by three experts.

B. Data Gathering Procedure

The process of gathering pertinent data in this study was guided by the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model, which is widely used in instructional design. Each phase of the model contributed to the systematic development and refinement of the Pre-Calculus Electronic Instructional Module (PEIM).

In the Analysis phase, a thorough assessment was conducted to identify the foundational requirements for the PEIM. An achievement test in Pre-Calculus was administered to 148 Grade 12 STEM students from Muntinlupa National High School during the school year 2021–2022. This test aimed to determine the least mastered competencies in Pre-Calculus, forming the basis for the module's content. Additionally, insights into the challenges faced by students during Modular Distance Learning were gathered through one-on-one, semi-structured interviews with 10 randomly selected students. These interviews provided valuable qualitative data, highlighting specific difficulties encountered in Pre-Calculus learning. To supplement this information, the educator-researcher reviewed instructional materials, journals, modules, and textbooks related to Pre-Calculus, ensuring that the module's content was comprehensive and aligned with educational standards.

Building on the findings of the Analysis phase, the Design phase focused on structuring and organizing the module. The outline and format of the PEIM were carefully crafted to ensure clarity and coherence. This outline incorporated the necessary components of the module, including an introductory message, learning objectives, pretest, lesson proper, generalization, application, and assessment. Additionally, to make the module engaging and interactive, features such as graphics, video clips, AI text-to-speech functionality, interactive activities, and quizzes were integrated. These elements aimed to address the identified challenges and enhance students' engagement and understanding of Pre-Calculus concepts.

In the Development phase, the researcher transformed the designed outline into a fully functional electronic instructional module. The content was developed based on the least mastered competencies identified during the Analysis phase. The module was created using tools such as Kotobee Author, Kotobee Reader, Microsoft PowerPoint, and Open Broadcaster Software, ensuring a user-friendly and technologically advanced product. During this phase, the initial validation of the PEIM was conducted by Pre-Calculus teachers and mathematics experts. Their evaluations provided critical feedback, which informed revisions and refinements, resulting in an improved version of the PEIM.

The Implementation phase involved the pilot testing of the developed PEIM with 80 Grade 11 STEM students. The pilot testing was conducted from March 2022 to May 2022 during the school year 2021–2022. Student-participants were oriented and given hands-on practice on how to use the PEIM, ensuring they could navigate the module effectively. To measure the impact of the PEIM, a pretest was administered before its use, followed by a posttest after the students completed the module. This phase provided crucial data on the module's effectiveness in improving student achievement in Pre-Calculus.

Finally, in the Evaluation phase, the PEIM underwent a comprehensive assessment to determine its overall quality and educational soundness. Pre-Calculus teachers, mathematics experts, and student-participants evaluated the module using the

Educational Soundness General Evaluation Checklist. Their feedback was instrumental in identifying strengths and areas for improvement. Additionally, 10 randomly selected students were interviewed to gather qualitative insights about their learning experiences with the PEIM. The suggestions and recommendations from both experts and students were integrated into the final revisions of the module, ensuring it met the highest standards of instructional quality.

This systematic approach through the ADDIE model ensured that the PEIM was carefully developed, thoroughly tested, and effectively evaluated to address the challenges of teaching and learning Pre-Calculus in a modular distance learning setting.

IV. RESULT AND DISCUSSIONS

A. Challenges Encountered by the Students in Learning Pre-Calculus

Distance learning offers flexibility and individualization by allowing learners and instructors to remain physically separated while instruction is delivered through various communication technologies. Modular distance learning, which relies on self-contained modules, was implemented as an emergency solution to continue education during the pandemic in the Philippines. However, students in Pre-Calculus faced numerous challenges in this setup.

One significant issue was **independent learning**, as students were required to study lessons on their own using printed or digital modules. Many struggled without teacher guidance or peer collaboration, resulting in misconceptions and difficulties linking new concepts to prior knowledge. One student shared, "Self-studying is already hard as it is, even more so during the pandemic." Another added, "I need to re-read and look for other learning materials just to understand the lesson." These challenges align with Rahmawati et al. (2019), who noted that a lack of learning resources hampers students' ability to study mathematics.

Limited teacher support was also a common concern. Students often depended on family members or online resources for assistance, as teachers were not always available to provide guidance. A student explained, "Sometimes, I message my engineer Uncle to teach me Pre-Cal." Another stated, "I search on Google or YouTube for explanations." The lack of direct teacher interaction is consistent with findings by Dejene and Chen (2019), who observed that insufficient feedback from teachers affects learning outcomes.

Adding to this issue was **feedback delay**, which hindered students from quickly correcting mistakes and understanding key concepts. A student shared, "I need to wait for my teacher's reply before I can continue my solutions in Pre-Calculus." Another explained, "I misunderstood one concept in my solution, and since I couldn't urgently ask the teacher, I got a low score on the summative test." Delayed feedback aligns with the findings of Butial et al. (2022), who noted that teachers faced challenges in providing timely support to students.

The **design of the modules** further increases the challenges. Many students found the modules boring, error-prone, and lacking interactive elements. One remarked, "Printed modules are plain and boring." Another mentioned, "There were times when I received repeated pages and missing pages." Similarly, Gonzales (2020) and Gueta and Janer (2021) observed that inaccuracies and overly lengthy content in self-learning modules made studying more difficult. Students suggested improvements, such as including visuals and concise explanations to enhance understanding.

Motivational challenges were another recurring theme, as the absence of a structured classroom environment led to procrastination and disengagement. A student admitted, "I don't open my math module until the deadline." Another stated, "Pre-Cal is already difficult for me; I cannot find myself motivated to open my module." This aligns with Barcenas and Bibon (2021), who highlighted that modular learners often struggled with time management and maintaining interest in their studies.

Limited interaction was also a challenge, as students missed the collaborative aspects of traditional classrooms. One student shared, "I learn best when I'm with my friends." Another added, "It is easier for me to learn when I have someone to accompany me." Wahyunigrum and Latifah (2020) similarly noted that reduced interaction in modular learning environments hindered students' ability to solve mathematical problems effectively.

Lastly, **limited access to resources** significantly impacted students' learning experiences. Poor internet connectivity and lack of digital devices restricted some students to printed modules. A student explained, "I can't open YouTube videos or participate in an online class since my location has poor internet signal." Another added, "We only borrow smartphones, so most of the time, I study using printed modules." This reflects findings by Castroverde and Acala (2021), who identified resource constraints as a major barrier to effective modular learning.

Overall, these challenges align with prior studies (Rahmawati et al., 2019; Schult et al., 2021; Mangulabnan, 2022), highlighting common difficulties such as independent learning, limited support, feedback delays, and engagement issues in modular distance learning. Addressing these concerns is essential for improving educational outcomes in this modality.

B. Least Mastered Competencies in Pre-Calculus

Table 1. Least Mastered Competencies in Pre-Calculus

Learning Competencies	Frequency of Error	Percentage	Rank
Illustrate the different circular functions.	95	64.19	1
Evaluate an inverse trigonometric expression.	92	62.16	2
Apply trigonometric identities to find other trigonometric values.	84	56.76	3
Solve trigonometric equations.	83	56.08	4
Solves situational problems involving conic sections	72	48.65	5
Determine the standard form of equation of a hyperbola.	70	47.30	6
Determine the standard form of equation of an ellipse.	69	46.62	7
Determine the standard form of equation of a parabola	68	45.95	8
Determine the standard form of equation of a circle.	66	44.59	9
Recognize the equation and important characteristics of the different types of conic sections	62	41.89	10

The study revealed the ten least mastered competencies of the students in Pre-Calculus as shown in Table 1. Given the students' low performance in the least mastered competencies, as presented in Table 1, the researcher designed and developed an electronic instructional module featuring engaging elements such as graphics, lectures, video lessons, interactive activities, and assessments. This e-module aims to provide a meaningful learning experience while enhancing the academic achievement of STEM students. Similarly, Pallera and Villanueva (2019) developed a tablet-based e-module targeting the least mastered competencies, which was proven to be highly effective in improving students' academic performance. In support of this, Nabayra (2020) emphasized that e-modules, as technology-enhanced instructional materials, offer students opportunities to address and enhance their understanding of the least mastered lessons in mathematics.

C. The Design and Development of Pre-Calculus Electronic Instructional Module by the Mathematics

The design of the Pre-Calculus Electronic Instructional Module (PEIM) was based on the Alternative Delivery Mode (ADM) module recommended by the Department of Education, which included the following parts:

Table 2. Parts of the Module Based on the Alternative Delivery Mode

Part	Description
Introductory Message	It contains instructions for the learner and for the facilitator on how to use the module.
What I Need to Know	It contains learning objectives to be developed in a material.
What I Know	This is given to check what the learner knows about the lesson to take.
What's In	Connects the current lesson with the previous lesson by going over concepts that were learned previously.
What's New	Introduces the new lesson through a situation or activity.
What is It	A brief discussion of the lesson. It aims to help the learners learn the new concepts and skills.
What's More	It consists of activities designed to improve learners' understanding and skills in the topic.
What I Have Learned	A question, fill in the blank sentence/paragraph to process what the learner learned from the lesson.
What I Can Do	An activity that shall transfer the skills/knowledge gained or learned into real-life concerns/situations.
Assessment	This evaluates the level of mastery of the learners in achieving the learning objectives.
Answer Key	It contains answers to all the activities in the material.
References	It includes all third-party materials or sources in developing the material.

Kotobee Author version 1.7.6 is the main software used in the development of the Pre-Calculus Electronic Instruction Module (PEIM). It is an interactive e-module creator and EPUB editor, suitable for education, training, and publishing.

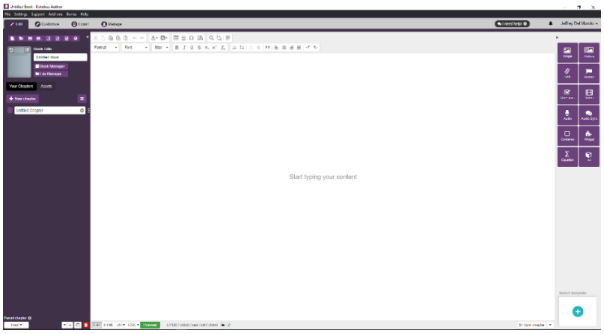

Figure 2. Kotobee Author version 1.7.6

The elements incorporated in the interactive e-module creator include images and graphics derived using Canva editor, Book widgets for interactive activities, video lessons produced and edited using Microsoft PowerPoint and Open Broadcaster Software, to enhance the students' learning in Pre-Calculus. The developed Pre-Calculus Electronic Instructional Module (PEIM) can be accessed by students on various devices, including smartphones, tablets, laptops, and computers, as long as they have the Kotobee Reader installed. Once downloaded, PEIM can be used offline. These tools were also utilized by Baring and Berame (2022) and Siano and Potane (2022) in the development of their e-modules.

The following are the interface of the Pre-Calculus Electronic Instructional Module (PEIM):

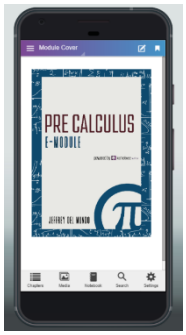

Figure 3. Kotobee Reader Screen

Kotobee Reader Screen. It shows the main working screen of the PEIM. Below are shortcut keys for Chapter, Media, Notebook, Search, and Setting.

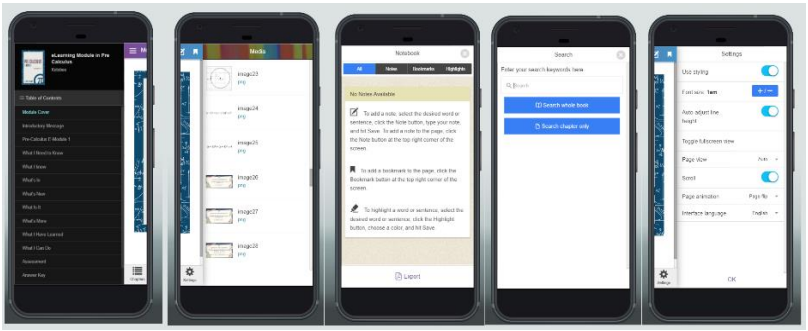

Figure 4. Parts of the Kotobee Reader Screen

a. **Chapters tab**. It opens the table of contents in the left panel.
b. **Media tab**. It opens a panel with a list of all media content in the book, such as images and video lessons.
c. **Notebook tab**. It opens a panel listing all the bookmarks, highlights, and notes taken by the student throughout the PEIM.
d. **Search tab**. It enables the student to search the whole PEIM and locate precise keyword positions.
e. **Settings tab**. It opens settings menu. The student may change the size, type, or color of the text, color of the background, view, and animation of the PEIM.

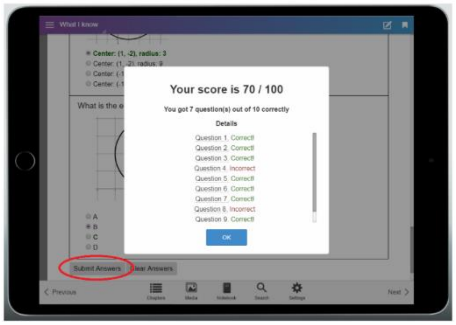

Figure 5. Submit Answers Option

Submit Answers Option. It is used to submit answers. It displays a detailed score report showing the correct and incorrect answers once clicked. Students could use this to master a drill or exercise on a specific topic. These features the interactive, individualized, and reflective parts of the PEIM.

Figure 6. Text-to-speech Option

Text-to-speech Option. Student can listen to the pronunciation of any word or sentence. A provision for students with sight impairment or for struggling readers.

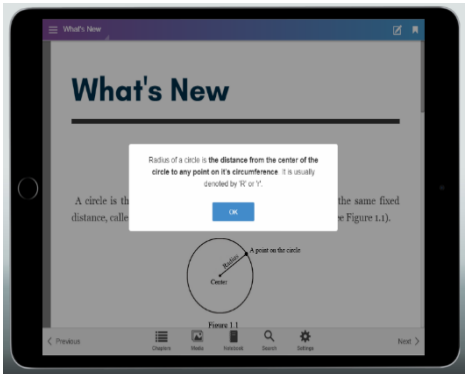

Figure 7. Onsite Dictionary

Onsite Dictionary. A pop-up message that defines unfamiliar word or displays an image associated with it. This aids in the vocabulary building of the lesson associated with audio-visual learning.

Figure 8. Video Lesson

Video Lesson. A video lesson that discusses the topic is included to enhance teaching and learning, particularly for visual and auditory learners. Video lessons, with their combination of visuals and narration, are often less complicated than written explanations, making them an effective tool for understanding basic concepts and problem-solving. Additionally, recorded video lessons allow students to learn at their own pace and adapt to their preferred learning style, as supported by Siano and Potane (2022). Similarly, Mangulabnan (2022) highlighted that video-aided learning modules promote student independence by providing clearer examples, being user-friendly, and effectively supporting the learning of mathematics.

Figure 9. Interactives

Interactives. An interactive activity, simple game, or puzzle that serves as a topic introduction or enrichment using Book Widgets. Teachers can use Book Widgets to create a different type of interactive content.

The Pre-Calculus Electronic Instructional Module (PEIM) exemplifies these principles as a digitalized module designed for individual learning, equipped with self-study guides. Unlike traditional printed modules, the PEIM integrates videos, audios, and animations, effectively embedding ICT into the learning process. This approach not only allows students to learn actively but also provides a dynamic and engaging educational experience, aligning with the demonstrated benefits of interactive e-modules. Incorporating activity and interactivity in e-modules has a significant impact on student engagement and learning. These elements enable students to actively engage with content, enhancing both comprehension and retention. Interactivity, such as quizzes, discussions, and drag-and-drop activities, fosters critical thinking and encourages students to apply their knowledge in real-world scenarios (Cakirca, 2022). Additionally, interactivity helps reduce cognitive load, allowing students to focus on the core material and leading to deeper learning (Das, 2020).

D. The Evaluation Rating of the Pre-Calculus Electronic Instructional Module by the Pre-Calculus Teachers and Mathematics Experts

Table 3. Result of the Evaluation Rating for Non-Print Materials

Factors	N	Mean	SD	Very Interpretation
A. Content Quality	10	3.88	0.09	Very Satisfactory
B. Instructional Quality	10	3.86	0.08	Very Satisfactory
C. Technical Quality	10	3.76	0.11	Very Satisfactory
D. Other Findings	10	3.83	0.16	Very Satisfactory

Pre-Calculus teachers and experts evaluated the Pre-Calculus Electronic Instructional Module as very satisfactory, based on the overall mean of 3.83 as shown in table 3. The weighted mean for different criteria on content quality is 3.88, instructional quality is 3.86, technical quality is 3.76 and other findings (conceptual, factual, grammatical, and other errors) is 3.83 which indicated a rating of Very Satisfactory. This means that Pre-Calculus teachers and Mathematics experts unanimously evaluated the electronic instructional module with high, or Very Satisfactory, remarks.

This confirms that the evaluators noticed that the content of the electronic instructional module is consistent with skills aligned to DepEd learning competencies for the Pre-Calculus subject. The content is accurate, up-to-date, logical, stimulates and promotes critical thinking, and advocates positive values (DepEd, 2020).

Based on the data, the quality of the instruction was deemed sufficient, as the purpose of the module and its learning objectives were well-defined, clearly stated, and measurable. The difficulty level of the module was labeled by the teachers as appropriate for senior high school students. Additionally, the graphics, colors, and sounds were considered suitable for the intended audience. The e-module was described as enjoyable, stimulating, challenging, and engaging, effectively fostering the creativity of senior high school students. Sweller et al. (2019) emphasized the role of graphics in managing cognitive load and reducing extraneous

cognitive load encountered by students. Similarly, the findings align with the study by Zurbano and Danila (2019), which highlighted the importance of catering to multiple intelligences and utilizing localized and contextualized content for easier understanding.

In terms of technical quality, the data indicate that teachers found the e-module to possess adequate and sound technical characteristics. The visuals, audio, and video were well-synchronized, enhancing the learners' understanding of the topic. The design and visual presentation were clear, easy to interpret, uncluttered, easy to read, aesthetically pleasing, and free from distractions, sustaining student interest. As emphasized by Bucholska (2021), interactive learning materials can increase learner engagement, provide opportunities to practice what has been learned, offer a safe environment for experimentation, and foster a willingness to learn.

Also, conceptual, factual, grammatical, typographical, and other errors were not present in the electronic instructional module as evaluated by the teachers and experts. This addresses the report of Magsabol (2020) about errors found in the learning modules during the opening week of the school year 2020 – 2021. This finding conforms to Manalastas and De Leon's (2021) study wherein their developed e-module got a remark of Very Satisfactory in the content quality, instructional quality, technical quality, and other findings.

Table 4. Evaluation Rating Sheet for Non-Print Materials

Factors	Pre-Calculus Teachers and Mathematics Experts (N = 10)
A. Content Quality	Passed
B. Instructional Quality	Passed
C. Technical Quality	Passed
D. Other Findings	Passed

Table 4 shows that all factors were marked as "Passed" in the evaluations by Pre-Calculus and Mathematics teachers. This indicates that the Pre-Calculus Electronic Instructional Module aligns with the topics outlined in the DepEd Learning Competencies. It further confirms the module's capability to support enrichment, reinforcement, and mastery of the identified learning objectives. The purpose of the material was well-defined, and the objectives were clearly stated. Additionally, the level of difficulty was deemed appropriate for the target users, offering enjoyable, stimulating, challenging, and engaging activities.

The visual presentations used in the module were clear, easy to interpret, accurate, and effective in helping students understand the concepts. Furthermore, the module was free from conceptual, factual, grammatical, and computational errors. Similar findings were reported in the studies of Hardeli et al. (2022), Baring and Berame (2022), Astalini et al. (2021), Pallera and Villanueva (2019), and Nabayra (2020).

E. Mathematics Achievement of the Students Before and After the Implementation of Pre-Calculus Electronic Instructional Modules (PEIM)

Table 5. Result on the Significant Difference between Pretest and Posttest Mean Scores

	Mean	Mean Difference	t-value	p-value	interpretation
Pretest	10.28	13.32	48.475	.0000	Significant
Posttest	23.6				

As shown in Table 5, the pretest mean is 10.28, while the posttest mean is 23.6, resulting in a mean difference of 13.32. The computed t-value is 48.475, and the p-value is .0000, which is less than the 0.05 level of significance. Therefore, there is a significant difference in the mathematics achievement of the students before and after the implementation of the Pre-Calculus Electronic Instructional Module (PEIM). This indicates that students performed better in Pre-Calculus after the implementation of PEIM.

Similar findings were observed in the study by Siano and Potane (2022) on the effects of interactive e-books in teaching mathematics to improve students' academic achievement. The results of their study showed that an interactive e-book via Kotobee Author significantly improved students' academic performance. They concluded that e-books could be effectively used by mathematics teachers to facilitate change in their classrooms, especially those implementing blended learning. This is also supported by the studies of Baring and Berame (2022) and Zurbano and Danila (2019).

F. The Evaluation Rating of the Educational Soundness of the Pre-Calculus Electronic Instructional Module

Table 6. Result of Educational Soundness General Evaluation of Pre-Calculus Teachers and Mathematics Experts (n=10)

Educational Soundness Specification	Mean	SD	Interpretation
A. Integrity	3.77	0.05	Very Satisfactory
B. Learner Focus	3.76	0.09	Very Satisfactory
C. Usability	3.9	0.1	Very Satisfactory
D. Accessibility	3.68	0.16	Very Satisfactory
Overall Mean	3.78		Very Satisfactory

From the data shown in table 6, the overall mean of 3.78 revealed that teachers and experts were very satisfied on the four (4) factors of Educational Qualities of the Pre-Calculus Electronic Instructional Module (PEIM). It indicates that Pre-Calculus teachers and mathematics experts evaluated very satisfactory on the integrity ($\bar{x}$=3.77), learner focus ($\bar{x}$=3.76), usability ($\bar{x}$=3.9) and accessibility ($\bar{x}$=3.68) of the electronic instructional modules in Pre-Calculus.

Factor C, "Usability," received the highest mean and was verbally interpreted as "Very Satisfactory." As evaluated by the teachers and experts, the PEIM is easy to use, and the language is appropriate for the intended user. Clear instructions are provided, and the learning and information design is intuitive.

Factor D, "Accessibility," marked the lowest mean, but was also verbally described as "Very Satisfactory." This implies that the teachers and experts found the PEIM can be accessed by learners in deprived and underserved areas and communities. The PEIM does not embarrass learners in any form and ensures that information is available for all types of learners with diverse needs.

As an electronic instructional module, the simplicity in the use of the PEIM was considered. The use of each navigation tool was clearly explained. Mantaluk et al. (2012, as cited in Manalastas, 2021) concluded that the use of a teaching module contributed high level thinking skills among students. This module also enabled students to achieve better performance toward learning. Integrity in instructional design ensures the content is accurate, valid, and ethically sound by adhering to evidence-based practices that promote transparency, fairness, and alignment with learning outcomes (Edutopia, 2022; Flying Cloud Solutions, 2022).

Table 7. Result of Educational Soundness General Evaluation of Students (n=80)

Educational Soundness Specification	Mean	SD	Interpretation
A. Integrity	3.70	0.05	Very Satisfactory
B. Learner Focus	3.65	0.05	Very Satisfactory
C. Usability	3.74	0.01	Very Satisfactory
D. Accessibility	3.56	0.12	Very Satisfactory
Overall Mean	3.66		Very Satisfactory

Table 7 shows that students were very satisfied with the four factors of Educational Qualities of the Pre-Calculus Electronic Instructional Module, with an overall mean of 3.66. This indicates that students were very satisfied with the integrity ($\bar{x}$ = 3.70), learner focus ($\bar{x}$ = 3.65), usability ($\bar{x}$ = 3.74), and accessibility ($\bar{x}$ = 3.56) of the module.

Factor C, "Usability," received the highest mean, with a verbal interpretation of "Very Satisfactory." Students evaluated the PEIM as having clear instructions, where users understood what to do and how to do it. Additionally, the time and effort required to use the PEIM were deemed reasonable.

Factor D, "Accessibility," received the lowest mean but was still interpreted as "Very Satisfactory." According to the students, the PEIM can be effectively used in varied learning environments without requiring intervention, and it is accessible even in deprived areas.

The accessibility of e-modules, which consist of various media such as text, images, graphics, animation, video, and interaction, maximizes teaching and learning time by allowing students to learn independently anytime and anywhere (Artiniasih et al., 2019). Furthermore, the use of video lessons, as noted by Yakubova (2020), provides a student-centered approach that enables learners to progress at their own pace, develop higher-order thinking skills, and enhance problem-solving by applying their own strategies to the material.

Table 8. Recommendation of Pre-Calculus Teachers, Mathematics Experts and Students

Educational Soundness General Evaluation Checklist	Pre-calculus Teachers and Mathematics Experts (n=10)	Students (n=80)
Recommend reproduction and distribution in current format. Resource acceptable as is	8 (80%)	70 (87.5%)
Resource requires modification before being reproduced.	2 (20%)	10 (12.5%)
Do not reproduce. Resource does not meet specifications.	0 (0%)	0 (0%)

Percentages of the recommendation of Pre-Calculus teachers, Mathematics experts and students on the Pre-Calculus Electronic Instruction Material (PEIM) is presented in Table 8. As can be seen from the mentioned table, most of the students, Pre-Calculus teachers and mathematics experts recommend reproduction and distribution in current format and the resource is also acceptable as it is. 8 out of 10 (80%) of the Pre-Calculus teachers and mathematics experts and 70 out of 80 (87.5%) of the students agreed to this. Only 2 out of 10 (20%) of the Pre-Calculus teachers and mathematics experts and 10 out of 80 (12.5%) of the students suggest that the resource requires modification before being reproduced. And no one outright rejecting the resource. This reflects a high level of educational soundness and acceptability of the PEIM.

The studies support the recommendation for developing e-modules as effective tools for enhancing student learning. Aksan (2021) suggests that learning kits should continue post-pandemic due to their positive impact on student attitudes. Basilio and Sigua (2022) highlight the success of multimedia-based e-modules in improving science performance, while Salas-Rueda et al. (2020) and Cardente (2023) demonstrate how structured models like ADDIE can optimize e-module development. Studies by Baring and Berame (2022) and Siano and Potane (2022) show that e-modules improve student performance and motivation in subjects like science and mathematics. These findings underscore the effectiveness of e-modules and support their development for improving student outcomes.

G. Students' Experiences on the Implementation of Precalculus Electronic Instructional Modules (PEIM)

Students were amazed, enjoyed, and felt at ease with the PEIM. According to one of the student participants, "It's highly useful and enjoyable to use" because of its feature making it digitally available. Students cited many benefits they may get from this Electronic Instructional Module in Pre-Calculus. They highlighted that the application used "… to open the module allows me to take notes, add bookmarks, and highlight text from it." The Pre-Calculus Electronic Instructional Module is organized as already included and integrated with the videos, content, and quizzes. Students describe it as, "it's an all-in-one package where videos and quizzes are all integrated in the module," and "the layout, graphics associated, and even videos for us to watch are all in the file."

Students describe the PEIM as convenient and easy to access. The PEIM integrates Information and Communications Technology into printed modules to enhance their uses and functionality. Students noted, "Its features make it a lot more convenient in terms of answering, watching videos, viewing photos, etc." and "What I liked about this e-learning module in Pre-Calculus is that it is easy to access since once it's downloaded, I can open the module anytime because of its availability offline." Another student also compares it to other current practices, "It is more convenient for us than before when we had to use YouTube, PowerPoint presentations, and PDF downloads to fully comprehend the module." Student participants also mentioned the incorporated video lesson in the modules. Short videos provided in every example excite the students as it has become helpful, especially for the students who have difficulties understanding the topic. Following are remarks from the learners. "Learners can watch videos to understand the lesson more;" "Prof D's video lessons made Pre-Calculus easier for me;" "Using video lessons with Pre-Calculus lectures allow me to comprehend information more quickly and recall information more easily;" and "I could see and hear the lesson being taught as if I was actually in the classroom and listening to the teacher."

Students also emphasized that the developed e-module promotes metacognition and provides the opportunity for them to think critically. As they mentioned, "It is challenging because there's a lot of exercises and tests that needed to be solved and answered;" "E-modules require students to think critically;" and "A lot of sample questions and assessments make me think deeply and critically." Moreover, students give comments on the content of modules, according to them, "the definition of every term are well explained and the formulas and solutions are explained clearly and precisely;" "topics were well defined, and the examples provided were sufficient to help us grasp how to derive the solution and lesson;" and "the steps are well explained and give multiple ways to solve the problem."

The special features of the electronic module were observed by the students. They comment on the technical quality of the Pre-Calculus Electronic Instructional Module such as, "you can easily zoom in on the photos; answering bottom or in paragraph form is also smooth;" "it is easy to navigate and there are many options we can change in this e-module learning material are very clear and can zoom up for a clearer view;" and "you can change the setting according to your preference and quiz are very interactive!"

Overall, the students' experience with the Pre-Calculus Electronic Instructional Module helps them to overcome the difficulty through the organized, detailed, interactive activity, unique features, and video lessons. For them, "overall, it's a great app to use as an alternative;" "very informative that every student can catch up;" "so far, this is the greatest strategy that my teachers have allowed for me to experience;" "it's simple and very interactive;" "features available in this Kotobee app is quite impressive;" and "I could rate the e-module as 10/10."

It conforms to the findings of Cox (2017) that technology makes students' learning more interesting and fun through virtual lessons and video. Furthermore, Trilestari and Almunawaroh (2020) and Siano and Potane (2022) claimed that e-module help students and teachers enrich the teaching and learning experience.

V. CONCLUSIONS

Students faced challenges in learning Pre-Calculus through modular distance learning. Addressing these issues requires the development of more interactive, engaging, and equitable educational strategies to enhance the effectiveness and accessibility of modular distance learning. Because of this problem, not all STEM students performed well in all the competencies in the subject Pre-Calculus as reflected by their least mastered competencies. Thus, a developed Pre-Calculus Electronic Instructional Module is Kotobee Author-Based and Alternative Delivery Mode (ADM) designed module. It also suggests a new method of the teaching-learning process in the modular distance learning modality. The developed Pre-Calculus Electronic Instructional Module attained "Passed" and "Very Satisfactory" ratings from Pre-Calculus and mathematics teachers in terms of different criteria: content quality, instructional quality, technical quality, and other findings. This indicates that all criteria under each factor in the evaluation of the PEIM were successfully met and satisfied. The use of Pre-Calculus Electronic Instruction Module (PEIM) as the learning resources tends to improve the achievement of the students in Pre-Calculus. The Pre-Calculus teachers, mathematics experts, and students evaluated the Pre-Calculus electronic instructional modules as "Very Satisfactory" on the following criteria: integrity, learner focus, usability, and accessibility. This implies that the developed Pre-Calculus Electronic Instructional Module exhibited high educational qualities. Majority of the Pre-Calculus teachers, mathematics experts, and students recommended the reproduction and distribution of the developed Pre-calculus Electronic Instructional Modules (PEIM) in its current format. This indicates that the PEIM is fully prepared for use as one of the learning resources in Pre-Calculus. Furthermore, Pre-Calculus Electronic Instructional Module (PEIM) gave positive experiences in the learning of the students. Therefore, using PEIM in teaching encouraged students to engage in Pre-Calculus learning.

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