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Development and Validation of Predict, Discuss, Explain, Observe, Discuss and Explain-Based Module in Selected Topics in Pre-Calculus

A Master's Thesis Presented to the Faculty of the Graduate Program School of Teacher Education the National Teachers College

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Abstract: This study aimed to develop and validate a PDEODE-based module in selected topics in Pre-calculus. This was initiated to enhance the poor performance of learners who are taking the STEM strand, particularly in STI College Global City. The developmental mixed method was utilized in this study. To gain a deeper understanding of the research problem, a sequential exploratory design was used. In the qualitative part of the study, the needs analysis was utilized in determining the selected topics in precalculus. The ADDIE Model was employed in the development of the module. The module lesson contained the following parts: learning objectives and trivia, the pre-test, the predict phase, the discuss phase, the explain phase, the observe phase, the discuss phase, the explain phase, and the post-test. In the quantitative part, the experts in the field of mathematics and research well as the mathematics teachers of STI College Global City, evaluated the module in terms of the suitability of content and objectives, instructional design, layout and format, and approach and level of difficulty.

Results of the study showed that all the teachers strongly agreed that the developed PDEODE-based module in selected topics in Pre-calculus met all the criteria found in each parameter on the validation tool. In addition, it was found that the mathematics performance of the students was enhanced and using the paired t-test with a 0.05 level of significance it is statistically proven that there is a significant difference in the scores of the students under the trial phase of the PDEODE-based module in selected topics in Pre-calculus. Therefore, it was concluded that the developed module is effective in enhancing the mathematical performance of the learners and teaching the pre-calculus subject.

Keywords: *PDEODE Teaching Strategy, PDEODE-Based Module, Pre-Calculus, Addie Model, STI College Global City.*

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I. THE PROBLEM AND ITS BACKGROUND

➢ *Introduction*

Pre-calculus is one of the foundations for learners pursuing careers in the fields of science, technology, engineering, and mathematics. In the Philippine education system, precalculus is offered to Grade 11 senior high school learners. Although some topics in precalculus are already taught in junior high school, many studies have shown that in the past few years, there has been an increasing concern about the declining performance in learners' understanding of mathematical concepts and critical thinking. This decline is due to many factors, including the lack of effective teaching strategies and the generic nature of current modules or teaching materials. The current modules used to teach pre-calculus often rely on traditional teaching methods that are no longer effective in engaging learners and promoting deep understanding.

The use of problem-based education has been gaining attention as a promising teaching strategy that can help address the problems faced by learners in pre-calculus. One of these problem-based education teaching strategies is the Predict, Discuss, Explain, Observe, Discuss, and Explain (PDEODE) teaching strategy. The teaching strategy was originally used in science education; the researcher in this study explored how the teaching strategy affected the mathematical performances of learners in pre-calculus. By

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using the PDEODE teaching strategy, learners are encouraged to think critically, solve problems, and apply mathematical concepts to real-world scenarios. Despite its potential benefits, the PDEODE teaching strategy is not yet widely adopted in Philippine education.

Teaching the learners to think critically requires significant effort. It also requires proper teaching methodologies and strategies because it has a major impact on teaching mathematics. We all agree that proper teaching strategies in mathematics are beneficial to improving learners' mathematics performance. This applies not only to mathematics but also to other subjects. The PDEODE teaching strategy, which is founded on constructivist learning principles, is one of the strategies that can enhance learners' performance in mathematics. The strategy is described as a collection of instructional techniques that promote the debate of various viewpoints and the development of an interactive environment in the classroom.

When the K-12 was implemented in 2016, tons of modules for pre-calculus were published. However, the currently available modules used in pre-calculus education are often generic and do not consider learners' diverse needs and backgrounds. As a result, many learners struggle to understand and apply mathematical concepts, leading to low grades and high dropout rates. To address this problem, there is a need to develop and validate PDEODE-based modules that are specifically designed for a pre-calculus class.

Private schools in the Philippines are open to formulating and developing modules that can be used in their schools. However, private schools are encouraged to align the modules with the most essential learning competencies of the Department of Education. The objective of this study is to develop and validate a PDEODE-based module for pre-calculus using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The ADDIE model is a systematic approach to instructional design that ensures that the module is learner-centered, relevant, and effective. By using the ADDIE model, this study aims to develop a PDEODE-based module that is tailored to the needs of pre-calculus learners and addresses the gap in current modules.

- *Background of the Study*

STI Colleges has 64 branches in different locations in the Philippines. This school has been known for its vision and mission of providing world-class education and real training since its beginnings in 1983. This school has its own learning system, namely the Electronic Learning Management System (ELMS). The school offers basic education at the elementary, secondary, and tertiary levels.

One of the branches of this school is STI College Global City, located in Taguig City. In this branch, the school offers senior high school and tertiary education. Moreover, STI College Global City uses the ELMS to deliver its learning system. Teachers on this campus are required to use the learning system as a minimum guide and as a source of activities. It means that teachers on this campus must have in-depth knowledge of the subjects that they are teaching. The courseware is not enough to sustain the academic needs of the learners, especially in mathematics. In senior high school, they have a STEM strand and an ABM strand for the school year 2024-2025. On the said campus, there are eight mathematics instructors and six sections under the STEM strand and three ABM sections. The curriculum of the school was also based on the Most Efficient Learning Competencies (MELC) of the Department of Education. Mathematics teachers in the said campus have the freedom to teach with the teaching strategies they are comfortable with. They can also use different learning materials such as modules and books to deliver the lessons inside the classroom.

Going back to the precalculus that was raised in the previous argument, there is no specific teaching strategy on how to teach the said topic in STI College Global City. Teachers used their own teaching methods to deliver their subject. Teachers are integrating the use of applications like GeoGebra and Mathway in the classroom. But there's still a problem with how to improve the mathematics performances of the learners.

In STI College Global City, there is no entrance exam or qualifying test for incoming Grade 11; with this, learners can enroll in whatever strand they want. Unfortunately, more learners found mathematics very challenging once they were enrolled in the STEM strand. This results in poor performance and the failure of learners in assessment tests. In this research study, the researcher utilized the developed PDEODE-based module in one of the sections of the STEM strand of STI College Global City. The PDEODE-based module aims to enhance the mathematics performance of the learners. Although the PDEODE teaching strategy is not that familiar in the Philippines, many foreign studies suggest and recommend to try the effectiveness of the teaching strategy in different field.

With the development of the PDEODE-based module and experiment, the researcher investigated how the module infused with the PDEODE teaching strategy enhanced the mathematics performance of the selected grade 11 STEM learners in selected topics in pre-calculus. The research was done during the trial phase of implementing the PDEODE-based module. This is measured based on the findings of the administered pretest and posttests. The goal of this research is to measure the effectiveness of the PDEODE-based module in STI College Global City. This teaching strategy (PDEODE) may also be adopted by the STI Colleges as the unique teaching strategy for all its campuses to enhance its learners' academic performance, not only in mathematics but also in other subject areas.

- *Theoretical Framework*

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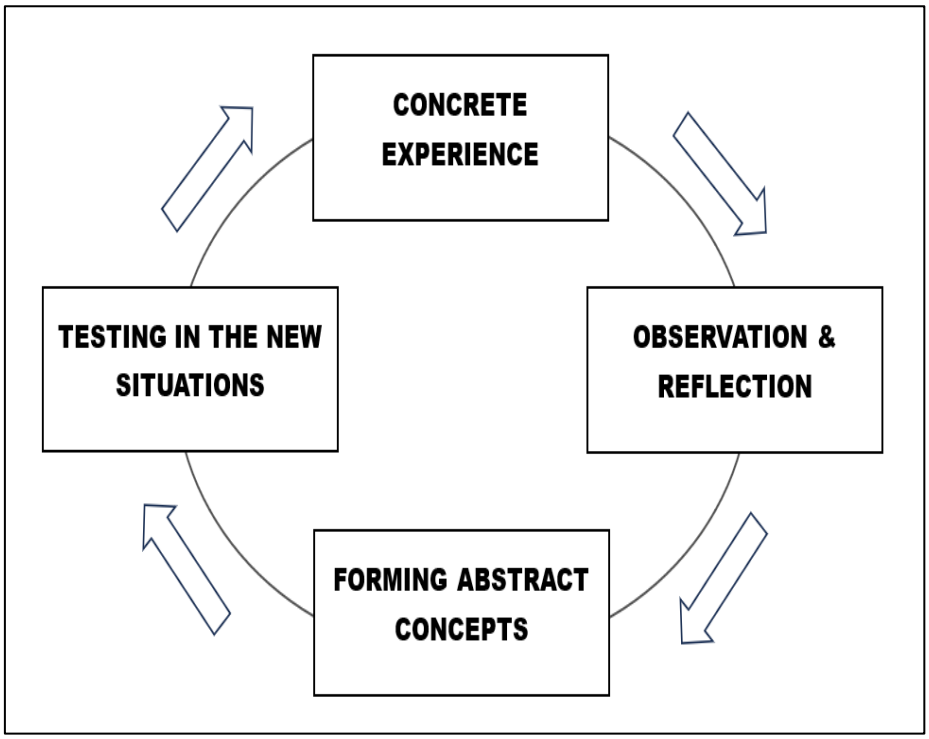

Fig 1 The Constructivist Learning Theory

In the PDEODE teaching strategies first phase, which is the Predict, learners are encouraged to think about their predictions, observations, and ideas about the topic being presented. In this phase students are builders of concrete experience and engaged, active participants in the activity. Bruner added that learners tend to learn with their previous knowledge based on their experiences, which they reflect on to incorporate new ideas and develop hypotheses. The second phase of the said teaching strategy is the Discuss. Learners are instructed to relay or discuss their ideas, predictions, or observations with their groupmates. In this phase learners can validate their previous knowledge by comparing it to their classmates'. The theory of constructivist learning is vital to understanding how learners learn. The idea that learners actively construct new knowledge is central to constructivism. Therefore, through the discuss phase, learners can construct new knowledge based on the ideas of their classmates.

In the mentioned theory, Bruner set up principles as follows: First, instruction must be concerned with the experiences and contexts that make the student willing and able to learn. Second, instruction must be structured so learners can grasp it easily. The organization emphasizes the importance of revisiting and building upon previously learned concepts. Third, instruction should be designed to facilitate extrapolation and/or fill in the gaps.

In the Explain phase of the teaching strategy, the teacher is now setting up a positive learning environment and starts to correct if there's a mistake during the Predictor Discuss phase. This is very crucial because teachers must be active listeners during the Predict and Discuss phase in order to address mistakes (if any). This is anchored to the idea of the constructivist that instruction must be concerned with the experiences and contexts that make the student willing and able to learn. In this phase, the teacher can add his/her insights about the topic being presented. Also, a short lecture by the teacher can be done in this phase. In the Observe phase, the teacher assists the learners in making observations that are relevant to the newly introduced concept. As Bruner emphasized, learners must revisit and build on previously learned concepts, as this is important in learning.

Next is the Discuss phase. In order to adjust their predictions based on the real observations they had previously documented, the learners must analyze, contrast, and critique one another's ideas, according to the teacher. And lastly, explain when learners encounter discrepancies between observations and predictions, they are able to accurately interpret the information. As stated in the principles of Bruner, instruction should be designed to facilitate extrapolation and/or fill in the gaps. In the last two stages, learners can revisit their answers in the predict stage and adjust their knowledge. Moreover, new knowledge and ideas will be explained in the last stage to assess the learning.

- *Conceptual Framework*

In this part of the study, the researchers presented the development of the PDEODE-based module using the ADDIE model. The ADDIE Model has 5 phases: the Analysis, Design, Development, Implementation, and Evaluation. The framework below showed how the PDEODE based module be developed and validated. With the use of the ADDIE model a well-crafted module was developed to enhance the mathematics performance of the learners.

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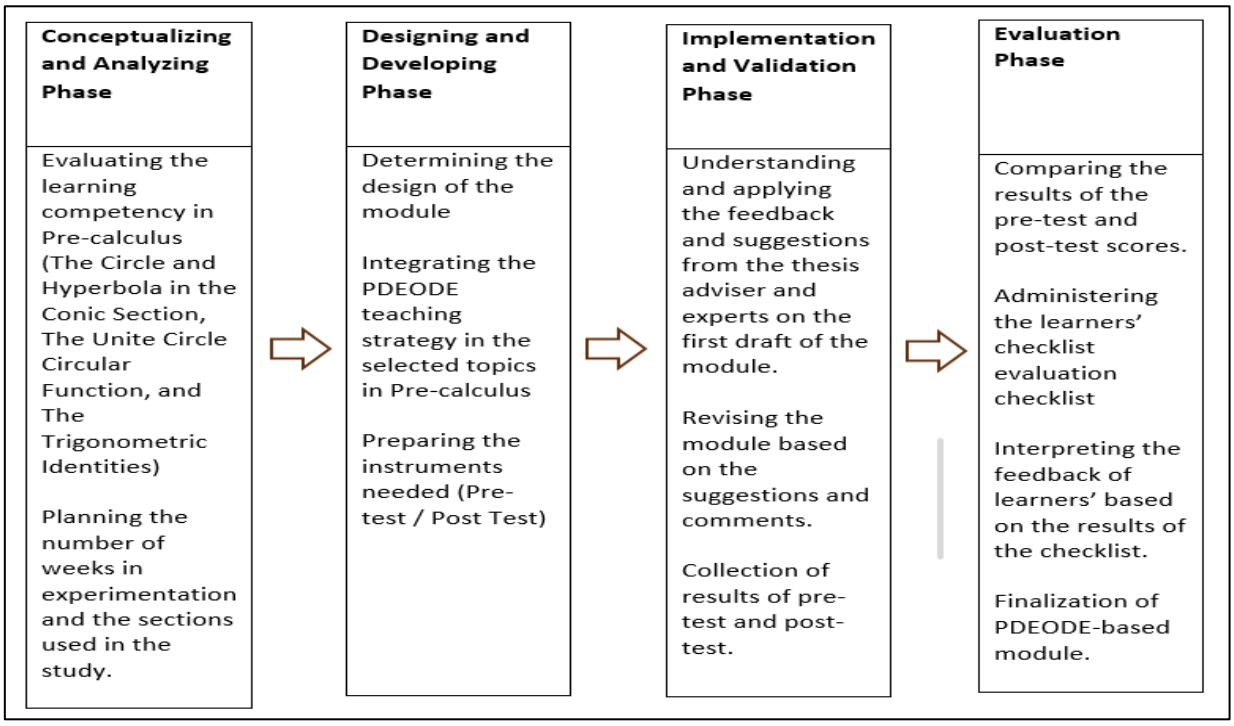

Fig 2 Development of PDEODE-Based Module Using the ADDIE Model

In the analysis phase, the researcher carefully examines the PDEODE teaching strategy and the pre-calculus curriculum. Through the needs analysis, the researcher conducted a survey of selected STEM students to gather their perceptions about precalculus. The strengths and limitations of the teaching strategy have also been analyzed, as well as the components of the PDEODE teaching strategy. As observed in the framework, the researcher combined the design and development phases; the gathered data in the survey about the teaching styles was used to design the module. Combining the different student-centered activities and the integration of the six phases of the PDEODE teaching strategy was observed in the design and development of the module.

In the implementation and validation phase, the module underwent a validation process through the help of five different experts in the field of mathematics and research education. After applying all the suggestions, a revision was made. One STEM section in STI College Global City was used to pilot the module. The chosen section was composed of 43 learners, but only 34 learners opted to participate in the study. Lastly, the evaluation phase. The module was rated by eight mathematics teachers of STI College Global City in terms of suitability of content and objectives, instructional design, format and layout, and level of difficulty. After gathering and interpreting the results based on the pilot experimentation, the PDEODE-based module will undergo finalization.

➢ *Statement of the Problem*

The study aimed to determine the mathematical performance of grade 11 STEM learners through the developed module integrated with the PDEODE teaching strategy. Specifically, the study sought to answer the following questions:

- What are the procedures and considerations in the development of the PDEODE-based module?
- How may the PDEODE-based module be validated in terms of:

✓ suitability of content and objectives
✓ instructional design
✓ Layout and format
✓ approach and level of difficulty

- Is there a significant difference between the mathematical performance of the learners in the trial phase of the developed PDEODE-based module?
- What is the level of effectiveness of the PDEODE-based module as perceived by the students?

II. METHODOLOGY

➢ *Research Design*

This study utilized a developmental mixed method. One of the objectives of this study is to develop a PDEODE-based module in selected topics in precalculus. In order to achieve this objective, the researcher used the ADDIE model as a guide to craft a well-designed and unique module for precalculus. A mixed method, or a combination of qualitative research and quantitative research approaches, was used in order for the researcher to gather the data needed in this study.

The exploratory sequential design was employed in this research. The exploratory sequential design is a type of research design that started with a qualitative approach followed by the quantitative approach. The qualitative approach was conducted to determine and analyze the needs

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and perceptions of the respondents in precalculus. A survey questionnaire was distributed to Grade 12 students to gather the data needed. Afterwards, the needs analysis was used to analyze the perceptions of the respondents. The quantitative approach was used to determine the effectiveness of the developed PDEODE-based module through the use of survey questionnaires. Moreover, to test the hypothesis, the researcher analyzed the results of the pretest and posttest scores of the learners in the trial phase of the PDEODE-based module.

➢ *Population and Sampling*

The total number of Grade 12 STEM students in STI College Global City is 160. The researcher used simple random sampling to gather the data needed in the needs assessment for precalculus. There are a total of 8 mathematics teachers in the said school. The researcher used complete enumeration or total enumeration sampling. Enumeration sampling is a type of purposive sampling used to collect as much data as needed to provide the deeper information needed for the study. And lastly, the totality of Grade 11 learners is 289. The researcher also used complete enumeration or total enumeration sampling. The mentioned sampling technique is the most suitable technique in the study to measure the effectiveness of the PDEODE-based module. Moreover, the learners in STI College Global City came from different backgrounds. The learners in the mentioned school are diverse; getting responses from different learners will eradicate bias from the study.

➢ *Participants of the Study*

The participants of the study were Grade 12 STEM students. These are learners who already passed precalculus during their Grade 11. The participants were composed of 114 students who answered a survey questionnaire that was used by the researcher to gather the perceptions of the learners about precalculus. The questionnaire is composed of 8 questions. Most of the questions are open-ended, allowing the respondents to give their feedback about their previous experiences and how they learn precalculus. The perception about the easiest and hardest topics in conic sections and the most essential topics under trigonometry were also collected. Needs analysis was used to analyze the responses of the learners; the gathered data were used as the basis for the selection of the topics in precalculus.

➢ *Respondents of the Study*

The respondents of the study are the mathematics teachers of STI College Global City and one section of the Grade 11 STEM strand. The mathematics teachers rated the effectiveness of the PDEODE-based module while the Grade 11 learners were the respondents in the trial phase of the module.

The mathematics teachers of STI College Global City are composed of 8 respondents. The group rated the effectiveness of the PDEODE-based module in terms of suitability of content and objectives, instructional design, layout and format, and level of difficulty. The results were used to measure the effectiveness of the PDEODE-based module in precalculus.

The Grade 11 STEM learners were composed of 34 learners. This group underwent experimentation within 5 weeks in the pilot testing of the PDEODE-based module. The group was used to measure the effectiveness of the module based on the results of the trial phase. The group answered the pre-test and post-test prepared by the researcher. The participants of the study were Grade 11 learners under the Science, Technology, Engineering, and Mathematics (STEM) Strand of STI College Global City, Taguig. One section was selected among the six sections during the school year 2024-2025. The class size of the chosen section is 43, but nine of the students opted not to participate in the study. So, there are a total of 34 students who participated in the study.

➢ *Research Instrument*

- *The Needs Assessment Tool for Pre-Calculus*

The needs assessment tool for pre-calculus was used to analyze the perception of the Grade 12 learners. These learners had already passed their precalculus subject; their responses were used to determine the selected topics in precalculus. This instrument is composed of 8 questions. Most of the questions are open-ended, allowing the respondents to give their feedback about their previous experiences and how they learn precalculus, especially the conic sections. The material was validated by five experts in the field of mathematics and education.

- *The Teachers' Assessment on the Effectiveness of the PDEODE-Based Module*

The teachers' assessment on the effectiveness of the PDEODE-based module is a survey instrument that measures the effectiveness of the module in terms of suitability of content and objectives, instructional design, layout and format, and level of difficulty. This instrument is composed of four sections. Each section has eight indicators. The reliability result of this instrument using Cronbach's alpha is 0.957, which is interpreted as excellent or very high. It showed that the indicators in each section of the instrument are highly consistent and reliable. The interpretation guide in this instrument is shown below.

Table 1 The Interpretation Guide for The Teachers' Assessment on the Effectiveness of the PDEODE-Based Module

POINT	INTERVAL	INTERPRETATIONS
5	4.20-5.00	Strongly Agree
4	3.40-4.19	Agree
3	2.60-3.39	Moderately Agree
2	1.80-2.59	Disagree
1	1.00-1.79	Strongly Disagree

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As shown in the table, the researcher used a five-point Likert scale. In the table, if the weighted mean falls between 4.21 and 5.00, the verbal interpretation is strongly agree. However, if the weighted falls between 1.00 and 1.79, the verbal interpretation is strongly disagree. It is also observed that the range between the intervals is consistent. This is to ensure no bias while interpreting the data.

- *The Summative Test*

In order to collect and measure the effectiveness of the PDOEDE-based module, the researcher constructed a 50-item multiple-choice questionnaire for the selected topic in precalculus, designed to assess the knowledge of the learners. The summative test was validated by different experts in the field of mathematics and experts in the field of research. After the consolidation of all the recommendations and suggestions of the validators, the researcher revised the summative test by applying all the recommendations and suggestions based on the responses of the validators. The summative test and table of specifications are attached in the appendices. Twenty volunteers from Grade 12 students answered the summative test. They answered the test within a maximum of seventy-five (75) minutes. Scores were tallied and secured with confidentiality. Afterwards, using Cronbach's alpha in SPSS, the reliability was calculated. The computed Cronbach coefficient is 0.756, with a verbal interpretation of acceptable.

- *The Effectiveness of the PDEODE-Based Module Survey*

The effectiveness of the PDEODE-based module survey was used to measure the overall effectiveness of the module based on the perception of the learners in the trial phase. The instrument is composed of ten questions. The instrument was validated by five experts. After the consolidation of all the recommendations and suggestions of the validators, the researcher revised the summative test by applying all the recommendations and suggestions based on the responses of the validators. The survey was answered by 10 different individuals to check the reliability. The computed Cronbach coefficient is 0.757, with a verbal interpretation of acceptable.

➢ *Data Gathering Procedure*

In the 1st stage of data collection, the researcher conducted the pilot testing of the Summative Test and gathered perceptions of the Grade 12 STEM learners. On November 15, 2024, the researcher addressed a formal letter to the Office of the Academic Head of STI College Global City, Engr. Renia R. Matira, who also served as the principal of the senior high school department. After the approval, a survey was conducted of selected Grade 12 STEM learners to gather their perception about precalculus. The survey questionnaire contains the rating or assessment of their understanding of precalculus, their perception of the easiest and hardest topics in conic sections, and their perception of the most essential topics under trigonometry. Needs analysis was used to generalize the responses of the learners; this was used as the basis for the selection of the topics in precalculus.

A research participation concern form was distributed to the random twenty (20) Grade 12 STEM students to answer the summative test. Only students with signed parent consent forms took the test. The purpose of the summative test is to determine the reliability of the instrument.

The research participation consent form, a formal letter, was distributed to the parents of the participants. In the letter, it was stated the purpose of the study. This is to determine the effectiveness of the PDEODE-based module. A module that is infused with more student-centered activities to further enhance students' conceptual understanding and academic achievement. The procedure, benefits, and risks of joining the study were also mentioned. Participants are expected to answer the activities required in the module, the pre-test, and the post test. Whatever scores in the mentioned activities won't affect either the class standing or the academic deficiencies of the participants. Furthermore, assessments and observations made by the researcher won't interfere with the academic requirements that were given to you by this course. In the return slip portion, it is indicated the right of the participant to decline to join the study. The contact number and email of the researcher were also included for questions and clarification for the parents and students. If the parents will be needing assistance or if the parents would like to translate the letter in the language they prefer, they can reach the researcher by sending an email or contacting the mentioned number in the consent form. The researcher also advised the participants to message the researcher if they need assistance.

The researcher reiterated the context of the research participation concern form before administering the test. The researcher also added that test scores will only be used to get the reliability of the summative test through the Cronbach's alpha and assured that the test scores are confidential.

On the other hand, the STI College Global City uses the Electronic Learning Management System in delivering their learning instruction; the gathered data won't be stored in the ELMS. This is to ensure the confidentiality of the test scores. A traditional approach was implemented: paper and pen. The participants answered through the use of Zip Grade.

The 2nd stage is the pretest. A research participation consent form was provided and distributed among the targeted section of the study. The section was coming from the STEM strand. The concern form (Appendix B) has an option for if they will or will not participate in the experiment. An option for students who are below 18 years old was also provided. This is to ensure that the parents are well informed and to secure the privacy of the participants in compliance with the Data Privacy Act. An assent form was also distributed to the participants of the study.

- *The Assent Form*

It is a formal letter explaining the participation of the students. Since the majority of the participants are minors, this form indicates the willingness of the participants to be part of the study. Just like the consent form, the purpose, procedures, risks, and benefits of joining the study were also elaborated. In compliance with the Data Privacy Act of 2012, it is also stated that the confidentiality of the data that will be gathered. It is elaborated that the data gathered will be purely

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used for the purpose of the study. If participants will encounter or experience pressure or stress during the experiment, the participant has a right to withdraw from participating in the study. The guidance counselor or guidance associate is also available to help the students.

After retrieval of research participation forms and assent forms, the researcher administered pretests. The pretest was conducted on February 20, 2025, the first week of the experiment. Pretests were done with paper and pencil. The pre-tests were administered by the researcher. Before the test, the researcher instructed the learners to answer the questions honestly, and the tests were administered with strictness. During the test, learners are not allowed to go outside the testing room, and learners are not allowed to talk to other learners. After 75 minutes, the researcher collected the materials, the questionnaires, and the answers of the learners. After collecting the materials and answers from the learners, the researcher reiterated that the scores, answers, and responses of the participants are confidential and the results won't affect their academic grades, and the responses will only be used purely for the study.

The 3rd stage is the trial phase or validation of the PDEODE-based module. On February 27, 2025, the researcher provided a hard copy of the PDEODE-based module to each learner. This is a week after conducting the pretest, the second week of the experiment. This week, the researcher discussed the first lesson in the module, which is the circle. The learners used the PDEODE-based module for the entire duration of the discussion. As discussed, the module was integrated with the PDEODE teaching strategy. On March 6, 2025, the third week of the experiment. The teacher used the PDEODE-based module in discussing the hyperbola. On March 13, 2025, the fourth week of the experiment. The teacher used the PDEODE-based module in discussing the unit circle, circular functions, and trigonometric identities. The 4th stage is the post-test. On March 20, 2025, the fifth week of the experiment. After the integration of the PDEODE- based module in the classroom. The researcher administered the posttest; just like the pretest, the posttest was administered through paper and pen. The test was conducted with strictness; the same guidelines were observed during the pre-test. The test is good for 75 minutes. After the post-test, the learners answered a survey questionnaire designed to assess the PDEODE-based module based on the perception of the learners. The researcher collected the materials, the questionnaires, and the answers of the learners.

After the collection of materials, the **debriefing process** was commenced. In the debriefing process, the researcher reiterated the purpose of the study. By participating in the research, they are helping the research community yet not compromising their identity. The researcher assured once again the confidentiality of the scores and responses of the participants. The participants will be informed about the publication of the gathered data. With this, the researcher emphasized that only aggregate data will be published. Meaning, the names of the students nor their identity will not be disclosed.

The 5th stage is the storing of gathered data. To secure the confidentiality of the collected data, all the results in the test made by the learners were input into Microsoft Excel. The file was protected by securing a strong password to ensure confidentiality. Names of the respondents were changed into codes; the last six digits of the student number of the respondents were used. The data was analyzed and interpreted. Data analysis is one of the crucial parts of the study; manipulation of data can occur in this stage. To avoid the manipulation and bias in the data, the researcher pledged not to change any scores of the participants and only use the data with honesty. After the interpretation and analysis of the stored data, the data are now ready for deletion. This assured the confidentiality of the responses shared by the participants.

➢ *Data Analysis*

To analyzed the data; the researcher used the percentage, weighted mean, mean, standard deviation, and paired t-test to measure the effectiveness of the developed module.

III. RESULTS AND DISCUSSION

➢ *The Development of the PDEODE-Based Module*

Table 2 Rating of Student-Respondents on their Understanding of Pre-Calculus

Rating		f	P
5	Fully understood	26	22.81
4	Mostly understood	42	36.84
3	Moderately understood	34	29.80
2	Slightly understood	9	7.89
1	Not at all understood	3	2.63
Total		**114**	**100.00**

Table 2 is entitled The Rating of the Student-Respondents on Their Understanding of Pre-calculus. As observed, 42 respondents, or 36.84%, rated their understanding as mostly understood, indicating that a significant part has a good understanding of precalculus. It is also observed that 2.63%, or 3 respondents, learned nothing during their precalculus class. Based on the respondents, many factors affected their understanding of precalculus. Respondents who mostly understood precalculus stated that the teaching strategies of the teachers greatly affected their understanding. Other respondents highlighted that the use of instructional material by the teachers helped them understand the subject. However, the data under "moderately understood is higher compared to "fully understood. It indicated that the

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respondents understand precalculus at an average level. This result is similar to the study conducted by Padernal and Diego (2020), where the researchers concluded that the learners in senior high school performed at an average level in precalculus. It is supported by Tarmizi (2010), a researcher outside the Philippines, who concluded that learners in calculus do not perform well, and this needs further attention and intervention.

Table 3 The Easiest and Hardest Kind of Conic Section to Understand

Easiest Topic in Conic Section			**Hardest Topic in Conic Section**		
Topics	**f**	**P**	**Topics**	**f**	**P**
Circle	85	74.56	Circle	3	2.63
Ellipse	10	8.77	Ellipse	22	19.30
Hyperbola	6	5.26	Hyperbola	62	62.00
Parabola	13	11.40	Parabola	27	23.68
Total	**114**	**100.00**	**Total**	**114**	**100.00**

Table 3 is entitled The Perception of the Student-Respondents on the Easiest and Hardest Kind of Conic Section to Understand. It can be observed on the left part of the table that 74.56% of the respondents answered circle. It shows that the larger part of the respondents found the circle easy to understand. On the other hand, only 5.25% of the respondents answered parabola as the easiest kind of conic section to understand. Observing the table on the right, it revealed that 62% of the respondents answered that hyperbolas as hard to understand. A noteworthy number of 2.63% answered that the Circle was hard to understand. Also, it can be seen that the results on the easiest kind of conic section are parallel to the hardest kind of conic section.

Based on the respondents, they found the circle to be the easiest to understand because the topic is already taught in Grade 10. The respondents also added that the procedures on how to solve the Circle are still fresh in their minds. On the other hand, the student's perception contradicts the opinion of the precalculus teachers of STI College Global City. It was found out that the majority of the students failed during the quiz about the Circle. One of the main factors might be the adjustment or transition of the students from junior high school to senior high school. Moreover, the student respondents found the hyperbola to be difficult to understand. It was found out that the steps in solving hyperbolas and the different terms made them feel overwhelmed. The respondents also added that teachers must use instructional materials or integrate technology to understand and appreciate the lesson. Similar to the suggestions of the teachers of the Senior High School Department that the school must provide additional tools to teach mathematics to enhance their teaching strategy. The teachers also added that the school must provide a mathematics room to conduct interventions and tutorials. The responses of both the teachers and learners are parallel to the study of Comighud (2021), which found that mathematics teachers are encouraged to use teaching strategies so that learners will be interested. This is supported by the study of de Jesus and Guzon (2022), which suggested that mathematics teachers are encouraged to increase the use of motivational strategies to gain the learners' interest and improve understanding.

Table 4 The Most Essential Topics Under Trigonometry

Areas Trigonometry	**f**	**P**
Definition of the Unit Circle	61	53.51
The Circular Function (Special Angles)	27	23.68
The Trigonometric Identities	15	13.16
Proving Identities	4	3.51
The Angle of Elevation and Depression	7	6.14
Total	**114**	**100**

Table 4 is entitled The Perception of Student-Respondents on the Most Essential Topics under Trigonometry. As observed majority of students answered the Unit Circle with 61 responses, or 53.51%, followed by the circular functions with 27 responses, or 23.68%. While proving identities and the angle of elevation and depression have the least responses, with 4 responses or 3.51% and 7 responses or 6.14%, respectively.

To sum up, the gathered data was used to develop the PDEODE-based module. Under the conic section, the circle and hyperbola were chosen. Based on the students' judgment, the circle is the easiest type of conic section to understand, while the hyperbola is the hardest. For trigonometry, the definition of a circle, the unit circle, fundamental identities, and proving trigonometric identities. All these topics are aligned with the most essential learning competencies of the Department of Education.

When the students were asked about the approach to how they understand pre-calculus, the following recommendations were highlighted: visual aids (diagrams, graphs), hands-on activities (projects, practical exercises), group work and discussions, practice problems and quizzes, and individual study or tutoring. It is supported by the study of Comighud (2021) that learners gained interest through various types of activities. The responses of the students are similar to the responses of the mathematics teacher of STI College Global City because the school focuses on collaboration and skill-based learning. As concluded by the

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study of de Jesus and Guzon (2022), mathematics teachers are encouraged to increase the use of motivational strategies to gain the learners' interest and improve understanding.

The perception and responses of the students were used in the selection of the topics in pre-calculus. In the conic section, the circle and hyperbola were chosen. Based on the responses of the students, the circle was found to be the easiest to understand among the four types of conics. However, it contradicts the responses of the teachers, according to them, the students got low scores in quizzes in the circle lesson. Moreover, the hyperbola is found to be the hardest to understand. With this, it will be determined if the module integrated with the PDEODE teaching strategy is effective in understanding the hyperbola. In trigonometry, the researcher adopted the top 3 responses on the most essential topic based on the responses of the respondents. That is the unit circle, circular function, and trigonometric identities.

After analyzing and determining the selected topics in pre-calculus, the design and development stage started. The cover page, table of contents, content overview, preface, overview about the PDEODE teaching strategy, how to use the module, and diagnostic assessment were carefully examined and crafted. The mentioned parts are part of the preliminaries of the module. In the content overview, it gives ideas and a glimpse to the learners of what to expect in the lessons. The preface discussed who and why the students should have the PDEODE-based module. The overview of the PDEODE teaching strategy gives the learners insights into how they are going to participate in the class discussion. The part, how to use the module will guide the students on how to properly use the module. Lastly, the diagnostic assessment will measure the existing knowledge of the students about the topic.

Every lesson in the module was integrated with the PDEODE teaching strategy. For example, in the circle, it started with the learning objectives and trivia about the circle. This was followed by the Pre-test 1. This test will measure the previous knowledge of the learners in the topic. Afterwards, the integration of the PDEODE teaching strategy was used to discuss the whole lesson. In Predict phase, (in this phase, active engagement is required, collaboration can be used to execute this phase) learners are asked about their prior knowledge about the circle by guessing the parts of the circle available on page 17 of the module. In the discuss phase, the learner is asked to brainstorm his/her ideas about the activity in the predict phase. In the explain phase, the learner is instructed to choose one classmate and explain their answers in front. In the Observe phase, the learner can ask for help from their classmates to answer and explore the missing part of the table in Exercise 2, page 19 of the module. In the Explain phase, the volunteer can answer the activities on page 22. The flow of discussion in every lesson in the PDEODE-based module was based on the principles of the PDEODE teaching strategy. The homework part is found after the last phase of the PDEODE teaching strategy. The post-test is also provided at the end of the lesson for the learners to assess their learning after using the module in every lesson. The answer keys for the diagnostic test and every pretest and posttest were provided in the final pages of the developed module. This is to provide the learners.

Therefore, the developed PDEODE-based module consisted of the following components. Under the preliminary pages, the cover page, table of contents, content overview, preface, overview about the PDEODE teaching strategy, how to use the module, and diagnostic assessment. In the selected topics in pre-calculus, with sub-parts, learning objectives, and trivia, the predict phase, discuss phase, explain phase, observe phase, discuss phase, explain phase and the post-test. Under the final pages are the answer keys and references.

- *The Validation of the PDEODE-Based Module*

Table 5 The Evaluation of the PDEODE-Based Module in Terms of the Suitability of Content and Objectives

	INDICATORS	WM	SD	VI
1	The content of the PDEODE-based module is relevant to the subject area.	4.88	0.35	Strongly Agree
2	The topics covered in the module represent the essential topics in precalculus.	4.63	0.74	Strongly Agree
3	The learning objectives of the PDEODE-based module are clearly defined and achievable.	4.38	0.74	Strongly Agree
4	The PDEODE-based module allows for the demonstration of knowledge and skills relevant to the subject area.	4.75	0.46	Strongly Agree
5	The activities and assessments provided in the module effectively support the learning objectives.	4.63	0.74	Strongly Agree
6	The structure and organization of the PDEODE-based module facilitate a logical flow of content.	4.63	0.52	Strongly Agree
7	The examples and problems used in the module can enhance understanding of how learners understand and master the content of the subject.	4.13	0.83	Agree
8	The depth of information presented in the PDEODE-based module is appropriate for the learners.	4.63	0.52	Strongly Agree
	GRAND WEIGHTED MEAN	**4.58**	**0.61**	**STRONGLY AGREE**

Table 5, entitled the evaluation of the PDEODE-based module in terms of the suitability of content and objectives, shows that teacher respondents from STI College Global City and experts in the field of mathematics and education strongly

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agreed with the content of the PDEODE-based module relevant to the subject area, with a weighted mean of 4.88 and a standard deviation of 0.35. On the other hand, the teacher respondents agreed that the examples and problems used in the module can enhance the understanding of the learners and master the content of the subject, with a weighted mean of 4.13 and a standard deviation of 0.83. In totality, the teacher respondents strongly agreed on the level of effectiveness of the PDEODE-based module in terms of the content of the module, with the grand weighted mean of 4.58 and a standard deviation of 0.61; therefore, the content of the PDEODE-based module is effective.

According to the respondents, the content of the PDEODE-based module is parallel to the ELMS courseware of STI College. The respondents also added that the modules' content is relevant and has enough information in order for the student to gain new knowledge. These characteristics are similar to the suggestions of Telaumbanua (2017) that modules must be well constructed and the content must be relevant so that the learners can build new knowledge.

Table 6 The Evaluation of the PDEODE-Based Module in Terms of Instructional Designs

	INDICATORS	WM	SD	VI
1	The PDEODE-based module was clearly organized and easy to follow.	4.50	0.53	Strongly Agree
2	The design incorporated a variety of multimedia elements to enhance learning.	4.25	1.04	Strongly Agree
3	The learning objectives were well-defined at the beginning of the module.	4.50	0.76	Strongly Agree
4	Opportunities for collaboration with peers were effectively integrated in the PDEODE-based module.	4.75	0.46	Strongly Agree
5	The pacing of the instruction was appropriate, allowing enough time for learning and reflection.	4.88	0.35	Strongly Agree
6	The PDEODE-based module forms a series of logical steps in the learning sequences.	4.75	0.46	Strongly Agree
7	All learning activities have been clearly planned and measure the knowledge, skills, and attitude of the learners.	4.38	0.74	Strongly Agree
8	The PDEODE-based module fostered an engaging and motivating learning environment.	4.38	0.74	Strongly Agree
	GRAND WEIGHTED MEAN	**4.55**	**0.64**	**STRONGLY AGREE**

Table 6 is entitled Evaluation of the PDEODE-Based Module in Terms of Instructional Design. It is revealed that the respondents strongly agreed that the pacing of the instruction was appropriate, allowing enough time for learning and reflection, with a weighted mean of 4.88. It also showed that the mentioned statement had the most consistent responses, having a standard deviation of 0.35. In totality, the faculty respondents strongly agreed on the effectiveness of the instructional design of the PDEODE-based module with a grand weighted mean of 4.55 and a standard deviation of 0.64; therefore, the instructional design of the PDEODE-based module is effective.

Torreffanca (2017) stated that instructional design of the developed modules must achieve the educational objectives as outlined in the curriculum. The design must include proper pacing of instruction that allows learners to grasp the lesson. It was similar in the comments of the respondents that developed the PDEODE-based module that allows the students to collaborate with other learners to achieve the set objectives. With the integration of the PDEODE teaching strategy, the learners have enough time to understand the lesson. These comments are similar to the suggestion of Wiesenfarth et al. (2018) that modules must be viewed as a single source of learning systematically. Allowing the learners to learn the lesson by giving them enough time and appropriate pacing to master the lesson.

Table 7 The Evaluation of the PDEODE-Based Module in terms of Layout and Format

	INDICATORS	WM	SD	VI
1	The layout and format of the PDEODE-based module are visually appealing.	4.75	0.46	Strongly Agree
2	The spacing between elements and words in the module is sufficient and enhances readability.	4.88	0.35	Strongly Agree
3	The use of colors is efficient and enhances the learner's experience.	4.63	0.52	Strongly Agree
4	The text sizes of the PDEODE-based module are appropriate and easy to read.	4.88	0.35	Strongly Agree
5	The layout of the pages is well-organized, making the whole PDEODE-based module appear interesting and easy to study.	4.75	0.46	Strongly Agree
6	The layout effectively guides the learner's attention to important information.	4.63	0.52	Strongly Agree
7	There is a consistency in the style of the module throughout the layout.	4.63	0.52	Strongly Agree
8	The PDEODE-based module concludes with a comprehensive summary of all main points.	4.50	0.76	Strongly Agree
	GRAND WEIGHTED MEAN	**4.70**	**0.49**	**STRONGLY AGREE**

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Table 7 is entitled The Evaluation of the PDEODE-Based Module in Terms of Layout and Format. It is revealed that the respondents strongly agreed that the spacing between elements and words in the module is sufficient and enhances readability, and the use of colors is efficient and enhances the learner's experience, with a weighted mean of 4.88. Both statements have the same standard deviation of 0.35, which shows that the mentioned statements have the most consistent responses. In totality, the faculty respondents strongly agreed on the effectiveness of the layout and format of the PDEODE-based module, with a grand weighted mean of 4.70 and a standard deviation of 0.49; therefore, the layout and format of the PDEODE-based module are effective.

According to the respondents, the PDEODE-based module has a consistent spacing between the elements, allowing the learners to read the module efficiently. The respondents also added that the colors used in the modules are appropriate to capture the interest of the learners. The responses are parallel with the suggestion of Torrefranca (2017), that the layout and format of the developed module must deliver relevant instructions by using proper spacing and proper color that is readable to various types of learners. This is supported by Akinoso (2018), who states that the elements of multimedia, which include text, colors, and graphics, aid the teaching and learning process.

Table 8 The Evaluation of the PDEODE-Based Module in Terms of Approach and Level of Difficulty

	INDICATORS	WM	SD	VI
1	The PDEODE teaching approach is appropriately integrated in the selected topics in precalculus.	4.75	0.46	Strongly Agree
2	The level of difficulty presented in the module is suitable for the understanding of the learners.	4.63	0.52	Strongly Agree
3	The PDEODE teaching approach is a good fit for achieving the objectives outlined.	4.63	0.74	Strongly Agree
4	The content of the PDEODE-based module is challenging, yet manageable within the given context.	4.63	0.52	Strongly Agree
5	The PDEODE teaching approach demonstrated the learner's understanding of the subject matter.	4.63	0.74	Strongly Agree
6	The learning objectives were clearly aligned with the level of difficulty presented.	4.13	0.83	Agree
7	I believe the strategies used were effective in helping the learner grasp difficult concepts.	4.63	0.52	Strongly Agree
8	The difficulty level was appropriate for the level and skills of the learners.	4.63	0.52	Strongly Agree
	GRAND WEIGHTED MEAN	**4.58**	**0.61**	**STRONGLY AGREE**

Table 8 is entitled The Evaluation of the Approach and Difficulty of the PDEODE-Based Module. It is revealed that the respondents strongly agreed that the PDEODE teaching approach is appropriately integrated in the selected topics in precalculus, with a weighted mean of 4.75 and a standard deviation of 0.55. In totality, the faculty respondents strongly agreed on the effectiveness of the approach and level of difficulty of the PDEODE-based module with a grand weighted mean of 4.58 and standard deviation of 0.61; therefore, the approach and level of difficulty of the PDEODE-based module is effective.

According to respondents, the PDEODE teaching strategy is an effective strategy because it accommodates diverse learning needs and styles and ensures inclusivity. This showed that the PDEODE teaching approach is appropriately integrated in the selected topics in precalculus. The respondents also added that the strategy promotes active participation, cooperation, and motivation among the learners. With this, regardless of the difficulty of the problems in the module, the learners can understand the topic. It is similar to the findings of Vergara (2017); he stated that modules must be self-learning. Regardless of the academic status of the learners, modules must be self-learned. It showed that the developed module using the PDEODE teaching strategy is self-learning and can be understood by learners with different backgrounds in mathematics.

- *The Significant Difference Between the Mathematical Performance of the Learners on the Trial Phase of the Developed PDEODE-Based Module*

Table 9 The Mathematical Performance of the Learners on the Trial Phase of the Developed PDEODE-Based Module

Variables	Mean	SD	T value	T critical	Decision
Pretest Result	16.26	4.10	±10.2799	±2.0345	Reject the Ho
Post test Result	23.59	5.82			

Looking at table 9, entitled The Mathematics Performance of the Learners on the Trial Phase of the Developed PDEODE-Based Module," It can be observed that the mean in the post-test, which was 23.59, was higher than in the pre-test, registered as 16.26. However, the consistency of the posttest result was lower than the pretest, with a standard deviation of 5.82 and 4.10, respectively, for the posttest and pretest. The mean and standard deviation show that there is an improvement in the scores of the respondents after using the PDEODE-based module. Moreover, the null

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hypothesis was rejected since the computed t-value of ±10.2799 was higher than the t-critical value of ±2.0345. Rejecting the null hypothesis means that there was a significant difference between the mathematical performances of the learners.

The results of the trial phase of the developed PDEODE-based module in selected topics in pre-calculus were similar to the study of Al-Kubaisi and Fakhri (2016). Their research found that the PDEODE method affected the fourth literature on learners' mathematical success and mental motivation. The outcomes demonstrated that there were significant statistical differences in the quasi-experiment. The 0.05 level between the two groups in the experimental group's favor on the mean achievement test and mean motivation scale scores. Another study conducted by Al-Shahrani (2018) shows applying the PDEODE approach is effective in scientific instruction in fostering success and imaginative thinking among elementary school pupils. Al-Shahrani's research discovered that using PDEODE in science education has an impact on the overall creative thinking of the learners.

➢ *The Level of Effectiveness of the PDEODE-Based Module as Perceived by the Students*

Table 10 The Overall Effectiveness of PDEODE-Based Module as Perceived by the Student Respondents

	INDICATORS	WM	SD	VI
1	I find the PDEODE-based module interesting and easy to understand.	4.41	0.61	Strongly Agree
2	I easily grasp the lesson using the PDEODE-based module.	4.12	0.64	Agree
3	With the use of the PDEODE-based module, the explanation and guidance of the teacher help me understand the lesson well.	4.62	0.60	Strongly Agree
4	All the phases (predict, discuss, explain, observe, discuss, explain) in the PDEODE-based module are well elaborated.	4.32	0.91	Strongly Agree
5	The exercises and activities in the module are relevant and understandable.	4.68	0.77	Strongly Agree
6	The layout and font size of the module are readable.	4.88	0.33	Strongly Agree
7	I clearly understand the selected topics in pre-calculus with the help of the module.	4.47	0.71	Strongly Agree
8	The PDEODE-based module can be used for various purposes and a wide range of students.	4.62	0.55	Strongly Agree
9	All aspects of the PDEODE-based module are well presented, giving a high probability that it will be a successful learning material.	4.59	0.61	Strongly Agree
10	In general, the PDEODE-based module appears to be interesting and likely to motivate students like me.	4.50	0.62	Strongly Agree
GRAND WEIGHTED MEAN		**4.52**	**0.63**	**STRONGLY AGREE**

Table 10 is entitled The Overall Effectiveness of the PDEODE-Based Module as Perceived by the Student-Respondents. It can be seen that the respondents strongly agreed that the layout and font size of the module are readable, with a weighted mean of 4.88 and a standard deviation of 0.33. On the other hand, the respondents agreed on the statement, I easily grasp the lesson using the PDEODE-based module," with a weighted mean of 4.12 and a standard deviation of 0.64. In totality, the student respondents strongly agree on the overall effectiveness of the PDEODE-based module, with the grand weighted mean of 4.52 and a standard deviation of 0.63; therefore, the PDEODE-based module is effective.

According to the respondents, the spacing between elements had sufficient space that made the modules' layout and font size readable. The respondents also highlighted that the information had different colors according to its needs, which made the module logically organized and visually appealing. These results helped the respondents gain interest in using the module. The conclusions are parallel to the study suggestion of Akinoso (2018) that the elements in the learning material, such as the font, text font size, and color used, helped the learners engage in the learning process. It shows that the developed PDEODE-based module helped the learners in their learning process.

IV. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

➢ *Summary*

- The considerations in developing the PDEODE-based module were as follows. First, 42, or 36.84%, of Grade 12 students mostly understood pre-calculus. Secondly, the easiest topic in pre-calculus was Circle, with a frequency of 85, or 74.56%, while the hardest topic was Hyperbola, with a frequency of 62, or 62.00%. Finally, the most essential topics in trigonometry were the definition of the unit circle, the circular functions, and trigonometric identities, with a frequency of 61, or 53.51%, 27, or 23.68%, and 15, or 13.16%, respectively.
- The evaluation of the PDEODE-based module in terms of suitability of content and objectives was strongly agreed upon by the respondents, with a grand weighted mean of 4.58 and standard deviation of 0.61. In terms of instructional designs, the respondents strongly agreed with the effectiveness of the module, with a grand weighted mean of 4.55 and a standard deviation of 0.64. Moreover, in terms of layout and format, the respondents strongly agreed with the effectiveness of the module with a grand weighted mean of 4.70 and a standard deviation of 0.49. Lastly, in terms of the approach and level of difficulty, the respondents strongly agreed with the

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effectiveness of the module with a grand weighted mean of 4.58 and a standard deviation of 0.61.
- There is a significant difference in the mathematical performance of the learners in the trial phase of the developed PDEODE-based module since the computed t value of ±10.2799 was higher than the critical value of ±2.0345.
- The level of effectiveness of the PDEODE-based module in terms of the overall effectiveness was strongly agreed upon by the student respondents, with a grand weighted mean of 4.52 and a standard deviation of 0.63.

➢ *Conclusions*

This research demonstrates the effectiveness of the PDEODE teaching strategy in selected topics in precalculus. The ADDIE Model was used to develop a module infused with the PDEODE teaching strategy. The mixed method was used in gathering the data needed in the study. In selecting the topics in precalculus, the researcher conducted a survey of selected learners who had already taken the precalculus subject. Afterwards, through the needs analysis, data was analyzed. The module was rated by the mathematics teachers of STI College Global City in terms of suitability of content and objectives, instructional design, layout and format, and level of difficulty. The trial phase was conducted in one section of STI College Global City. The perception of learners about the overall effectiveness of the module was also collected. Based on the findings, the following were concluded.

In the needs analysis, the circle, hyperbola, unit circle, circular function, and trigonometric identities were concluded as the selected topics in the PDEODE-based module.

The mathematics teachers of STI College Global City and experts in the field of mathematics and education rated the module from "strongly disagree to strongly agree" in terms of suitability of content and objectives, instructional design, layout and format, and level of difficulty. It was found out that the teachers strongly agreed on all the mentioned indicators.

In the trial phase of the PDEODE-based module, statistical data showed that there is a significant difference in the mathematics performance of the respondents. The performance of the learners was improved after the integration of the PDEODE-based module in the classroom.

The developed PDEODE-based module was rated from "strongly disagree to strongly agree" by the learner respondents in the trial phase in terms of the overall effectiveness of the module. It was found out that the learners strongly agreed in all the indicators. In conclusion, the module was rated effective by the learners.

➢ *Recommendations*

After careful interpretation and analysis of data, the study reveals the following recommendations:

For the learners, the developed PDEODE-based module was tested as effective in understanding precalculus. Every learner came from a different background; other learners are afraid of learning precalculus or found precalculus to be a difficult subject. Using this module will help the learners to understand the precalculus subject.

For the teachers, the PDEODE-based module was based on the constructivist approach, and throughout the years, it was found effective in teaching in the classroom setting. The module infused with the PDEODE teaching strategy will make your classroom more fun and engaging. Try exploring the use of the said teaching strategy in your classroom. For the mathematics teacher, integrating the module in your classroom is highly recommended to prove the effectiveness of the module.

For the school administrators, the PDEODE-based module is rich in collaborative learning styles and explanations for the students to understand the precalculus subject. This module will help the institution to achieve the learning competencies set for the students that are enrolled in the STEM strands.

For the parents, the developed PDEODE-based module was found effective in all types of learners. If you want to enroll your child in homeschool, the module can help so that your child can still meet the learning competencies set by the department of Education. The module can help the parents track the academic status of their child if they are doing the task given to the learners.

For the researchers of the future, in this research, the developed PDEODE-based module was used in selected topics in precalculus. The researcher recommends to future researchers to develop a PDEODE-based module for the entire course in precalculus. Exploring the development and validation of a PDEODE-based module for Grade 7 mathematics or any Grade level in junior high school mathematics is highly recommended. Embracing PDEODE teaching strategy in mathematics education is one way to improve the understanding of the learners in mathematics.

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