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Research Paper

Improving high school student's performance in basic calculus using the Enhancing Mastery & Expertise in Mathematics supplementary material

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Abstract

Preparing K-12 students to gear up for higher mathematics and sciences, and to be more mathematically college-ready, teachers were given the essential role in bridging the learning gaps. One way to address this was the utilization of modules. The researcher developed Enhancing Mastery & Expertise in Mathematics (EM&EM) module in Basic Calculus. The objective of this quasi-experimental research was to evaluate the effectiveness of the EM&EM module in improving students' performance about the theorems of differentiation. The experimental and comparison groups comprised forty-six (46) Grade 11 students who used the EM&EM module and the DepEd module, respectively. The instruments used in the study were the pretest, formative test, and posttest found in the EM&EM module. Mean and standard deviation was used to describe student performance in these assessments. To see if a significant difference existed, the formative test and post-test scores between the two groups were analyzed using an independent t-test, while the pretest and post-test scores within each group were analyzed using a paired sample t-test. The findings showed that the experimental and comparison groups' formative tests and posttest scores did not differ significantly, although the former generally performed better when their mean scores were compared. However, there was a significant difference between the two groups pretest and posttest scores, and that had a large positive effect on their improvement. Therefore, just like the DepEd module, the EM&EM module was effective in facilitating the learning process. Overall, the EM&EM module significantly and substantially enhanced students' learning of Basic Calculus.

Keywords *Learning Module, Basic Calculus, Intervention*

INTRODUCTION

Basic computation skills are a prerequisite for learning advanced and higher mathematics, but in the local setting, students often encounter difficulties in acquiring these skills. This situation was made evident by the different international examinations administered to Filipino students. In 2003, the Trends in International Mathematics and Science Study (TIMSS) revealed that Filipino second-year high school students ranked 41st in mathematics among the 46 participating countries (Imam, et al., 2013). This was one of the reasons why the Philippines adopted the K-12 Curriculum through Republic Act No. 10533. The implementation of the K-12 Curriculum was a response to the growing disparity between the education system in the Philippines and that of other countries, as evidenced by various international exams similar to TIMSS.

However, five years after the implementation of the K-12 Curriculum, the country's standing in mathematics education did not improve compared to neighboring countries. The 2018 Programme for International Student Assessment (PISA) revealed that the Philippines scored the lowest in reading comprehension and the second lowest in mathematics and science among the seventy-nine participating countries (San Juan, 2019). These results highlighted the consistently poor performance of the Philippines in comparison to other nations. This was alarming because the K-12 Curriculum which was designed to address this global gap was already in full implementation.

In 2019, the Philippines participated in the TIMSS again, but the country's scores in mathematics

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(297) and science (249) were significantly lower than those of any other participating country (Magsombol, 2020). These scores were the lowest among the 58 countries that took part in the study. These poor results in international exams highlight the need for further investigation into how mathematics education, particularly in the Philippines, can be improved. It is evident that Filipino learners still require continuous assistance in learning mathematics, as they appear to encounter difficulties.

Within the Senior High School curriculum, Grade 11 students who were enrolled in Science, Technology, Engineering, and Mathematics (STEM) study Basic Calculus. Calculus is a branch of mathematics that deals with the differentiation and integration of functions representing real-life processes and quantities. Differential calculus, a branch of calculus, focuses on how fast a quantity changes concerning another quantity. Its applications are diverse and extend to fields such as economics, science, and engineering.

Due to the wide-ranging applications of calculus, learners often face challenges in studying the subject. Studies by Wewe (2020) and Jaudinez (2019) have shown that students struggle with calculus due to a lack of mastery of its fundamental concepts. Additionally, Kartinah, et al. (2021) noted that this difficulty may arise from cognitive obstacles in learning calculus. While students can apply the lessons they already know to familiar situations, they often lack the knowledge necessary to solve new and challenging problems.

In addition to cognitive challenges, both teachers and students have experienced a lack of learning modules. Braza and Supapo (2014) identified the absence or late arrival of modules as a major problem in a rural high school in the Philippines, according to the school administration, teachers, and students. To address this issue, teachers improvised with available books and resources to ensure that learning continued. Estonato (2017) supported this observation, noting that the lack of instructional materials and facilities contributed to low acceptance of the K-12 curriculum among stakeholders.

In light of these concerns, the researcher decided to create a learning module that may further assist the students in learning the lessons in Basic Calculus, a specialized subject for STEM students. The present study measured the effectiveness of a researcher-made learning module about the theorems of differentiation called Enhancing Mastery & Expertise in Mathematics (EM&EM) learning module. While the Department of Education already provided a module for Basic Calculus that covered the Most Essential Learning Competencies (MELCs) and was divided into manageable chunks, the researcher suggests the EM&EM module that followed a different pedagogical model and incorporated online video tutorials to further assist students towards mastery in conceptual knowledge and procedural skills regarding the theorems of differentiation. This module would focus on discussing the basic theorems of algebraic functions first before moving on to other types of functions, such as transcendental functions. The researcher believes students must master the skills in algebraic derivatives before introducing the derivatives of transcendental functions. The present study aims to measure how this researcher-made module can enhance students' academic performance in the subject, to prepare them in understanding concepts of more advanced mathematics.

LITERATURE REVIEW

Difficulties in Teaching and Learning Calculus

Recognizing the need for an education system aligned with global standards, the Department of Education (DepEd) acknowledged the challenges faced by Filipino learners in their educational journey. These difficulties were further exacerbated in 2020 when DepEd transitioned to online classes as a response to the COVID-19 pandemic. Fauzi and Khusuma (2020) conducted a study and identified several problems hindering the effective implementation of online learning, including the unavailability of facilities and equipment, challenges with network and internet usage, issues related to evaluating learning outcomes, and the need for collaboration with parents to support student learning at home. Addressing these problems was crucial to ensure the continuity of learning in the remote setup.

Another study conducted by Basar et al. (2021) referred to the research of Wildana et al. (2020) that highlighted the effectiveness of online learning when utilizing various online applications and platforms such as Google Classroom, Zoom for video conferencing, and WhatsApp for communication. Nevertheless, it was also noted that limited internet access greatly hindered the effectiveness of online learning (Wildana et al., 2020).

Aside from the technical difficulties in carrying out online learning, students also face cognitive obstacles. In the light of calculus education, Kartinah et al (2021) narrated that cognitive obstacles occurred when an individual's previous knowledge, which was sufficient to solve a previous problem, became inadequate when encountering a new problem. Their study recommended that visual representations such as graphs assisted the students in arriving at correct problem solutions. (Kartinah et al., 2021)

Mathematics College Readiness of Grade 12 Graduates

The challenges in conceptual understanding of mathematics and the lack of learning modules have been identified as significant factors contributing to the low performance of Filipino students, both in global exams and in their local academic settings. Perante (2022) found that a majority of K-12 2020 graduates were not mathematically college-ready, indicating a lack of skills to prepare them for higher mathematics in college. The study found that only 43% of incoming first-year college engineering students in Eastern Visayas, who were K-12 graduates in 2020, were mathematically college-ready (MCR). The majority of the students (57%) were not mathematically college-ready (NMCR). Further analysis revealed that the least mastered math skill was found in basic calculus topics. Specifically, the study showed that the lessons on derivatives ranked fifth among the six senior high school mathematics lessons, with low performance. The specific lessons on the Quotient Rule and Product Rule were answered correctly by only 27% and 23% of the respondents, respectively. This is concerning because derivatives are fundamental concepts in calculus that serve as a basis for understanding advanced calculus and physics lessons.

Enhancements to mathematics instruction and the use of interactive instructional materials are crucial in preparing students for college mathematics. The Senior High School curriculum aimed to support students in their transition from basic to college education. A study by Amanonce (2020) found that students who had more exposure to mathematics during their basic education were significantly more prepared for college-level mathematics compared to those who only met the minimum requirements. This enhanced readiness contributed to their overall college readiness upon graduating from Grade 12. Therefore, if instructional modules provide rigorous mathematical exercises and teachers expose students to problem-solving situations, it can be inferred that students will be better prepared to learn higher-level mathematics at the tertiary level. A weak foundation in basic mathematics was identified as a contributing factor to students' lack of readiness, and this can be addressed through the use of instructional modules.

Strengths and Weaknesses of Instructional Modules

When appropriately designed, learning modules can guide students in independent learning. Telaumbanua, et al (2021) cited Suparman (2014) who revealed in his study that learning modules possess self-explanatory power. Moreover, modules have two distinctive features that benefit learners: they promote self-paced learning and are available anytime, anywhere. Modules should cover lessons in manageable units to prevent students from feeling overwhelmed when studying on their own (Torrefranca, 2017). The variety of materials included in the module, such as e-texts, online activities, and video links, encourages students to learn at their own pace. The availability of learning modules, whether in printed or digital form, provides students with flexibility and accountability in their learning. In addition, Ramdani et al. (2019) suggest that a well-written and comprehensive module can effectively explain a lesson to students. It can provide the necessary information and guidance for students to learn and understand the content.

Modules can serve as supplementary materials to guide both fast learners and academically challenged students. Based on the effectiveness demonstrated in her study, Columbano (2019) recommended using learning modules as enrichment exercises for fast learners and as enhancement tools for habitual absentees and academically challenged students. Modules have proven effective in optimizing students' learning in mathematics as they allow students to understand problems, principles, and processes through observation, analysis, and independent practice (Columbano, 2019). This approach allows learners to take ownership of their learning and can foster a sense of fulfillment and motivation.

In the context of calculus education, instructional materials, such as modules, can have a significant impact on student achievement. Gagto and Duran (2021) found that well-designed modules in pre-calculus and basic calculus can provide relevance to students' lives and motivate them to learn. The same authors also cited Effiong and Igiri (2015) who highlighted the importance of modules aligning with the curriculum, and students' learning styles, and incorporating a variety of media to promote intrinsic motivation and achievement in calculus.

On the other hand, it is important to acknowledge the potential disadvantages of using learning modules. Tombaga et al. (2021) identify several drawbacks, including the reliance on internet access, which can be problematic for students without stable connectivity at home. Independent learning through modules may also cause frustration and stress for students who are not accustomed to this mode of instruction. Additionally, students may face distractions at home, such as household chores or social media, which can hinder their learning if they do not manage their time wisely. Therefore, students need strong time management skills and motivation to effectively utilize modules (Tombaga et al., 2021).

In addition, Valderama's study (2012), cited by Tombaga et al. (2021), suggested that not all students may effectively succeed in modular instruction. The study found that students with low math ability experienced a decline in their achievement levels when exposed to modular instruction, while high math ability students were not affected.

Thus, while learning modules offer advantages such as flexibility, motivation, and personalized learning experiences, they can also present challenges related to internet access, independent learning, and distractions. The effectiveness of modular instruction may vary among different student groups, emphasizing the need for individualized support and consideration of students' abilities and learning preferences.

The present study dealt with quantifying the effects of the EM&EM learning module in basic calculus, particularly about the lessons in theorems of differentiation. Moreover, it was anchored on the 5E pedagogical model. The 5E Pedagogical Model suggests how teachers should design their

instruction to engage students in intellectually challenging endeavors. According to the Department of Education and Training in Melbourne, Australia (2020), Roger Bybee's five domains of instruction are as follows: Engage, Explore, Explain, Extend, and Evaluate. The model begins with the Engage stage, where students recall their prior knowledge through various activities provided by the teacher and investigate how the present lessons are related to it in the Explore stage. The teacher then corrects misconceptions, answers questions, and supports discussions in the Explain stage before generalizing the Extend stage. Finally, the teacher evaluates how much the students have learned in the Evaluate stage. It is important to note that these five domains of instruction are flexible units and should not be viewed as rigid, separate units for linear paths of learning (Department of Education and Training, 2020).
By providing a module that follows a structured pedagogical model and addresses the fundamental concepts before progressing to more complex topics, the researcher hopes to improve students' understanding and performance in Basic Calculus. The use of well-designed learning modules can serve as supplementary resources to support students in acquiring the necessary mathematical skills and knowledge, ultimately preparing them for higher mathematics and improving their overall academic performance.

RESEARCH METHOD

Research Methodology
Among the quasi-experimental research design, the study employed a Pretest-Posttest Non-equivalent Group Design, which involved selecting a comparison group that did not receive the treatment and an experimental group that received the treatment (Yazon, et al, 2019). This research design was appropriate to the present study because it compared the improvement in student learning as shown by the test scores between the two groups that used different materials during their respective classes. The treatment was the utilization of the researcher-made EM&EM module as supplemental material in hybrid learning of the experimental group, while the DepEd module was used by the comparison group. Pretests, formative tests, and posttest were administered to both groups to assess their performance.

Participants of the Study
The population of the study consisted of all Grade 11 students enrolled in the Science, Technology, Engineering, and Mathematics (STEM) strand in a private senior high school in Cabuyao, Laguna for the fourth quarter of the school year 2022-2023. From this population, a sample size was selected by randomly choosing two sections from the nine available sections. Table 1 presents the sample sizes of the two sections that participated in the study.

Table 1. Population and sample sizes of the experimental and comparison groups

	Number of Students Enrolled	Number of Selected Participants	Number of Blind Participants
Comparison Group	39	23	16
Experimental Group	41	23	18
Total	**80**	**46**	**34**

As presented in Table 1, the initial number of students in the comparison group was 39, but only 23 students qualified as participants in the study after the match-pairing sampling technique was applied, based on their pretest scores. The remaining 16 students were considered blind participants, meaning they were not included in the analysis. Similarly, in the experimental group, 23 out of the initial 41 students were considered participants, while the remaining 18 students were blind participants.

Research Instrument
The EM&EM learning module was based on the 5E pedagogical model. Thus, each lesson about the theorems of differentiation followed the format: Engage, Explore, Explain, Extend, Evaluate. Each part contained different web resources, readings, examples, and assessment items. To check the validity, the EM&EM module was checked using a validation tool that covered the following criteria: learning objectives, content, format and language, learning activities, and assessment. The researcher submitted the first draft of the EM&EM module and the validation tool to the research adviser for checking. Then, it was revised to follow his recommendations. Subsequently, the second draft of the EM&EM module and the validation tool were distributed to three expert teachers in the field of mathematics. The validation was done by a master teacher from the Division of Santa Rosa, a mathematics instructor, and an associate professor from the mathematics faculty of a private university in Cabuyao, Laguna. After retrieving the reviewed copy and the tool, the EM&EM module was edited for the last time based on their comments and suggestions.

Research Procedure
After revising the EM&EM module based on the comments of the validators, the data-gathering procedure immediately started.
On March 28, 2023, the students from the two chosen sections took the pretest before the start of the lesson about theorems of differentiation. The pretest was composed of 15-item multiple-choice questions about the fundamental theorems of differentiation on algebraic functions. The students' scores were used as the basis for the match-pairing. Among the 80 students, only 46 students (or 23 pairs) qualified to participate in the study after the match-pairing technique was carried out. Table 2 shows the result of the pretest of the two groups.

Table 2. Pretest Mean Scores of Comparison and Experimental Groups

Group	Mean	SD	Descriptive Interpretation
Experimental Group	5.609	3.340	Low
Comparison Group	5.609	3.340	Low

Legend: 14 – 15 = Very High; 11 – 13 = High; 8 – 10 = Average; 5 – 7 = Low; 1 – 4 = Very Low

As shown in Table 2, both the experimental group (Mean = 5.609, SD = 3.340) and the comparison group (Mean = 5.609, SD = 3.340) obtained low mean scores in the pretest, indicating a lack of knowledge regarding the lesson. The similarity in mean and standard deviation between the two groups can be attributed to the match-pairing sampling technique, which ensured that each score from the experimental group was paired with a corresponding score from the comparison group. This process resulted in two groups with identical pretest scores and a one-member-to-one-member correspondence.
Following the pretest, the experimental group utilized the EM&EM module in their Basic Calculus classes while the comparison group used the DepEd module. After each of the 3 lessons, formative tests were administered to both groups to check if the students understood the current theorem before discussing the next: the first formative test was administered after the lesson entitled "Basic Rules of Differentiation; the second was after the lesson entitled "Product Rule and Quotient Rule

of Differentiation; and the last was after the lesson entitled "Chain Rule of Differentiation". Each formative test was composed of 20-point open-ended mathematical questions that required the students to show their complete computation using the appropriate theorem discussed in the module. Finally, after all the lessons are discussed with the two groups using their respective supplementary materials, the students took the posttest. Like the pretest, the posttest consisted of 15-item multiple-choice questions about all the theorems of differentiation discussed. The items in the pretest and posttest were parallel to ensure consistency. Both groups answered the same posttest on April 28, 2023.

Statistical Treatment

The students' scores in all of these assessments were recorded, analyzed, and evaluated statistically using the following statistical tools: mean and standard deviation to describe the data; independent t-test to determine if there was a significant difference between the formative tests and post-test scores of the two groups; paired-samples t-test to assess if there was a significant difference between the pretest and posttest scores within each group; and Cohen's d to quantify the effect size of every significant difference present.

FINDINGS AND DISCUSSION

Formative Tests Scores of the Experimental and Comparison Groups

Table 3 shows the descriptive statistical measures for the scores of the comparison and experimental groups in the three formative tests.

Table 3. Formative Tests Mean Scores of Comparison and Experimental Groups

Lesson/Topic	No. of Points	Group	Mean	SD	Descriptive Interpretation
Basic Rules of Differentiation	20	Experimental	18.565	2.761	Very High
		Comparison	15.913	4.981	High
Product Rule and Quotient Rule of Differentiation	20	Experimental	17.565	3.057	High
		Comparison	18.000	4.503	Very High
Chain Rule of Differentiation	20	Experimental	18.174	2.462	Very High
		Comparison	17.957	2.836	High
Overall	60	Experimental	54.304	6.957	**Very High**
		Comparison	51.870	10.661	**High**

Legend: 18 – 20 = Very High; 15 – 17 = High; 10 – 14 = Average; 6 – 9 = Low; 1 – 5 = Very Low
54 – 60 = Very High; 45 – 53 = High; 30 – 44 = Average; 16 – 29 = Low; 1 – 15 = Very Low

As shown in Table 3, in the first formative test, the experimental group (Mean = 18.565, SD = 2.761) achieved a higher mean score than the comparison group (Mean = 15.913, SD = 4.981). This trend continued in the third formative test, with the experimental group (Mean = 18.174, SD = 2.462) outperforming the comparison group (Mean = 17.957, SD = 2.836). However, in the second formative test, the comparison group (Mean = 18.000, SD = 4.503) obtained a higher mean score than the experimental group (Mean = 17.565, SD = 3.057). Overall, the experimental group (Mean = 54.304, SD = 6.957) demonstrated a very high mean score compared to the comparison group (Mean = 51.870, SD = 10.661). These scores of the experimental and comparison groups supported the claim of Columbano (2019) who also investigated the improvement in student learning brought by the learning modules. His study highlighted that providing sufficient examples and activities, which may be in the form of formative assessments, may contribute to an effective modular approach in mathematics.

Posttest Scores of the Experimental and Comparison Groups

Moreover, Table 4 presents the post-test mean scores and standard deviation of the comparison and experimental groups.

Table 4. Posttest Mean Scores of Comparison and Experimental Groups

Group	Mean	SD	Descriptive Interpretation
Experimental Group	12.957	1.988	High
Comparison Group	12.783	2.194	High

Legend: 14 – 15 = Very High; 11 – 13 = High; 8 – 10 = Average; 5 – 7 = Low; 1 – 4 = Very Low

As presented in Table 4, between the experimental group (Mean = 12.957, SD = 1.988) and the comparison group (Mean = 12.783, SD = 2.194), the experimental group achieved a higher mean score. Additionally, the scores of the comparison group exhibited more variation, as indicated by their larger standard deviation, compared to the scores of the experimental group, which had a smaller standard deviation. These results were in line with the findings of the study of Torrefranca (2017) which showed how the module greatly increased students' understanding of the lesson as demonstrated by the scores in the pretest and posttest assessments.

Significant Difference Between the Formative Tests Mean Scores of the Two Groups

Next, Table 5 summarizes the results for significant differences between the formative test scores of the comparison and experimental groups.

Table 5. Test of significant difference between the formative test mean scores of the two groups

Topic	Group	Mean	SD	Mean Difference	t-value	Cohen's d
Basic Rules of Differentiation	Experimental	18.565	2.761	2.652	2.234	-
	Comparison	15.913	4.981			
Product Rule and Quotient Rule of Differentiation	Experimental	17.565	3.057	-0.435	-0.383	-
	Comparison	18.000	4.503			
Chain Rule of Differentiation	Experimental	18.174	2.462	0.217	0.278	-
	Comparison	17.957	2.836			
Overall	Experimental	18.101	2.761	0.811	1.328	-
	Comparison	17.290	4.260			

df = 44; Level of significance is 0.05

As stated in Table 5, the overall result of the three formative tests between the experimental group (Mean = 18.101, SD = 2.761) and the comparison group (Mean = 17.290, SD = 4.260) indicated no significant difference in terms of their mean scores, $t(44) = 1.238$, $p > 0.05$. Therefore, the null hypothesis was accepted, suggesting that both modules had similar effectiveness in assisting students in learning the theorems of differentiation. These formative assessments were conducted after each lesson to address the students' low mastery and understanding of the basic concepts of calculus, which is known to contribute to their difficulties in learning calculus. The insignificant differences between the two modules may be attributed to the quality of activities, media, and evaluation items for independent learning included in both modules (Telaumbanua, et al., 2017).

Significant Difference Between the Posttest Mean Scores of the Two Groups

Furthermore, Table 6 presents the results for the test of significant difference between the post-test scores of the two groups.

Table 6. Test of significant difference between the posttest mean scores of the two groups

Test	Group	Mean	SD	Mean Difference	t-value	Cohen's d
Posttest	Experimental	12.957	1.988	0.174	0.282	-
	Comparison	12.783	2.194			

df = 44; Level of significance is 0.05

According to Table 6, the posttest mean scores of the experimental group (Mean = 12.957, SD = 1.988) and the comparison group (Mean = 12.783, SD = 2.194) did not show a significant difference, $t(44) = 0.282$, $p > 0.05$. Consequently, the null hypothesis was accepted. This indicates that both the EM&EM and DepEd modules were equally effective in assisting students in achieving the competencies related to the theorems of differentiation. These results align with Torrefranca's (2017) assertion about the benefits of using a module as supplementary material in the classroom. When designed in manageable units, a learning module can encourage students to learn at their own pace, thereby facilitating meaningful learning (Torrefranca, 2017).

Significant Difference Between the Pretest and Posttest Mean Scores of Each Group

On the contrary, Table 7 shows the significant difference between the pretest and posttest scores of the experimental and the comparison groups.

Table 7. Test of significant difference between the pretest and posttest mean scores of each group

Group	Test	Mean	SD	Mean Difference	t-value	Cohen's d
Comparison	Posttest	12.783	2.194	7.174	9.691**	2.340 (Huge)
	Pretest	5.609	3.340			
Experimental	Posttest	12.957	1.988	7.348	8.151**	2.464 (Huge)
	Pretest	5.609	3.340			

*df = 22; **Significant at 0.05 level; Cohen's d: Very small (0.01), Small (0.20), Medium (0.50), Large (0.80), Very large (1.20), Huge (2.0)*

As summarized in Table 7, at the 0.05 level of significance, significant differences with a huge effect size were observed between the pretest (Mean = 5.609, SD = 3.340) and posttest scores (Mean = 12.783, SD = 2.194) of the comparison group, $t(22) = 9.691$, $d = 2.340$. Similarly, for the experimental group, there was a significant difference with a huge effect size between their pretest (Mean = 5.609, SD = 3.340) and posttest scores (Mean = 12.957, SD = 1.988), $t(22) = 8.151$, $d = 2.464$. These results indicated major changes and improvements in academic performance. Therefore, the null hypotheses were rejected, and significant differences were observed between the pretest and posttest scores of the experimental and control groups before and after the treatment.

These findings supported the study conducted by Columbano (2019), which emphasized the effectiveness of using a modular approach in teaching mathematics, especially when the module is written simply and logically with ample examples and activities for practice. The EM&EM module which was validated to be fit in assisting students towards the understanding of the theorems of differentiation indeed showed how it can be highly beneficial for the students.

Furthermore, the results present study were also aligned with the results of studies by Torrefranca (2017) and Gagto and Duran (2021), which demonstrated that modules could enhance achievement in mathematics when presented logically and utilized appropriately. Although they developed and validated their modules for their respective fields of specialization, all their findings about how effective and useful modules could be agreed with the result of the present study.

However, these results contradicted the findings of Valderama's (2012) study that was cited by Tombaga et al. (2021). In that study, it was suggested that students with low math ability may experience a decline in their achievement levels when exposed to a modular approach to teaching. This further emphasized the significance of the teachers as facilitators in the learning process. Regardless of the quantity and quality of supplementary materials, the teachers should still be present to assist the students by clearing any misconceptions they might have picked up from the learning module.

These results highlighted the benefits of the EM&EM module to student learning. The key difference between this module and the DepEd module was that the former contains web links to lecture videos that broke the monotony of continuous readings and created avenues for more diverse student activities. It was also presented using the 5E pedagogical model. This endeavor was not common to research studies, considering that there were numerous pedagogical models and areas of mathematics that had been the subject of earlier studies.

CONCLUSIONS

The development of a learning module similar to the EM&EM module was not the subject of numerous studies. This quasi-experimental research aimed to evaluate the effectiveness of the EM&EM module using pretest, formative test, and post-test scores of student participants. Indeed, it was revealed that the experimental group exhibited superior performance compared to the comparison group in the formative tests and the posttest. The paired-sample t-tests did not yield significant differences between the two groups. However, the independent t-tests revealed significant differences between the pretest and post-test mean scores for both groups, supporting the effectiveness of the Enhancing Mastery & Expertise in Mathematics (EM&EM) learning module in improving student learning in Basic Calculus.

The hypothesis stating that there is no significant difference between the formative tests' mean scores of the experimental and comparison groups was accepted. Despite being based on different pedagogical models, both the EM&EM learning module and the DepEd module demonstrated similar competencies.

Next, the hypothesis stating there is no significant difference between the posttest mean scores of the experimental and comparison groups was also accepted. Although the presentation and delivery of concepts in the EM&EM and DepEd modules differed, they covered the same scope of content, as they both assisted the students in learning the theorems of differentiation.

However, the hypothesis stating that there is no significant difference between the pretest and posttest mean scores of the experimental group was rejected. This learning was attributed to the utilization of the EM&EM learning module throughout the lectures, class discussions, and independent learning. The module proved effective in helping the students achieve the competencies related to the theorems of differentiation, as evidenced by the significant improvement in their post-test scores

Finally, the hypothesis stating that there is no significant difference between the pretest and posttest mean scores of the comparison group was rejected. The effect size was also huge, indicating that the DepEd module also brought about a significant change in student learning, similar to the impact of the EM&EM module on the experimental group.

LIMITATIONS & FURTHER RESEARCH

There had not been much research and studies concerning the creation, validation, and evaluation of a learning module in Basic Calculus that followed the 5E pedagogical model. This descriptive research focused on this objective and was able to prove that the EM&EM module positively assisted the students in learning the lessons about the theorems of differentiation.

Data utilized in this study were from the assessment scores of the students in their pretest, formative tests, and posttest, After careful statistical analysis, they showed positive results that confirmed the research objective. Thus, mathematics teachers may utilize the EM&EM module as a resource for enrichment activities for high-achieving students and as a repository of enhancement worksheets for students who are academically challenged. They may also integrate the content of both the EM&EM and DepEd modules into their lessons to provide a diverse range of learning experiences in the classroom.

The present study was only participated by 2 sections of Grade 11 STEM students. This was because only the Grade 11 STEM students take up the subject of Basic Calculus in Senior High School. Furthermore, the study did not consider other demographic profiles like gender, age, and economic status. Considering a larger sample size that is inclusive of these demographic profiles when creating the comparison and experimental groups with match-pairing as the sampling technique is recommended to enhance the reliability of data.

Moreover, the present study was only descriptive. Future researchers may consider creating an inferential study that investigates the effectiveness of other modules based on different pedagogical models in facilitating student learning in basic calculus. By structuring a learning module using a different pedagogical approach, researchers may examine the extent to which it supports student achievement and compare it with the results obtained using the EM&EM module.

Future researchers may explore the effectiveness of an improved version of the EM&EM module. This may involve adding more interactive features for independent learning, providing additional formative assessments for independent practice, incorporating real-life applications of the lessons, and expanding the module to cover other topics in basic calculus, particularly those for the entire third and fourth quarters.

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