Journal of Mathematics and Science Teacher
2024, 4(2), em060
e-ISSN: 2752-6054
https://www.mathsciteacher.com/

MODESTUM

Research Article

OPEN ACCESS

Enhancing students' performance on least taught topics in basic calculus through Moodle-based courseware package

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Citation: Evardo Jr, O. J., & Itaas, E. C. (2024). Enhancing students' performance on least taught topics in basic calculus through Moodle-based courseware package. *Journal of Mathematics and Science Teacher, 4*(2), em060. https://doi.org/10.29333/mathsciteacher/14310

ARTICLE INFO

Received: 18 Jul. 2023

Accepted: 15 Feb. 2024

ABSTRACT

This study utilized the developmental research design to identify the least taught topics in basic calculus and design and investigate the effectiveness of a Moodle-based courseware package. Data were collected from seven basic calculus teachers and five academic administrators through survey questionnaires, interviews, and validation sheets. The quasi-experimental phase of the study used a pre-/post-test control group design with a sample of 69 students, 34 students in the experimental group and 35 students in the control group. The experimental group received instruction using an asynchronous Moodle-based courseware package, while the control group received instruction through lecture notes. Results showed that the least taught topics include infinite limits, limits at infinity, and limits of trigonometric, exponential, and logarithmic functions. These topics were least taught due to time constraints, students' capacity, scheduling, complexity, and relatability. Validation of the courseware package showed a very high validity. It was found that the use of Moodle-based courseware package and lecture notes effectively increased the students' performance. However, one-way analysis of covariance results showed that the experimental group gained considerably greater than those in the control group. It was recommended that teachers continue to update their knowledge of different teaching methodologies to develop an encouraging and dynamic learning environment.

Keywords: Moodle, courseware package, basic calculus, least taught topics, mathematics performance

INTRODUCTION

Great things are the product of patience, preparation, and time. It is a fact that calculus is one of the difficult subjects (Estonanto & Dio, 2019), especially for those who encounter the subject for the first time. Calculus requires a lot of patience and practice, so it necessitates ample time to be taught and learned. Senior high school has been included in the curriculum as part of the K-12 reforms in Philippine basic education in order to keep up with graduates from other countries. As a result, some tertiary-level subjects were transferred to senior high school, particularly basic calculus for the science, technology, engineering, and mathematics (STEM) strand (Tambaoan & Gaylo, 2019).

In 2016, department of education released the curriculum guide for basic calculus, which indicated that the subject would be taught in a total of 80 hours. However, in reality, it is not attainable to teach all of the subject's content within the indicated timeframe. The problem stems from the congested curriculum; too many topics are needed to cover within a very short period. Additionally, the prolonged celebration of an athletic event (Billonid et al., 2020), school closures due to weather and natural catastrophes, absenteeism, and any other reason for absence (Kuhfeld et al., 2020), holidays associated with regionally recognized festivals (Gonzales, 2017), and the readiness of the students to proceed to the next topic are some of the factors why basic calculus teachers find it challenging to deliver the subject's content. As a result, some topics in basic calculus are left untaught (Batilantes, 2023). Basic calculus teachers would only choose the essential topics and completely ignore the others. This is dangerous because such topics are pre-requisite for higher mathematics and physics. If some topics were skipped, it would create a gap and affect the students' future understanding of mathematics.

When COVID-19 struck in early 2020, educational institutions were forced to shift to different modalities and adapt technology in teaching and learning (Anzaldo, 2021). With the COVID-19 pandemic, educators realized the benefits of learning management systems (LMSs), which explored the idea of remote, asynchronous, online, and offline learning. With such technology, teaching and learning are no longer confined to the four corners of the classroom. With the pandemic about to end, educational institutions are slowly transitioning back to full face-to-face, enhanced by technology. Most institutions use an LMS to supplement the face-to-face teaching and learning process. Through such LMSs, students nowadays have the capacity to access the subject's content anytime and anywhere. These LMSs have great potential for successfully organizing students' independent work (Anatolievna, 2018).

The use of LMS in education has been recognized internationally. According to Bradley (2021), the learning process is strengthened by LMS through a virtual educational environment. Moreover, the use of an LMS gives online students constant feedback on their performance (Nasser et al., 2011), sustain engagement (Al-Fraihat et al., 2020), and enables independent learning for students (Anatolievna, 2018). Empirical studies worldwide found that students have a favorable view of LMS and that it facilitates the learning process (Rahman et al., 2019), the use of LMS increased students' mathematics critical thinking ability (Ramadhani et al., 2020), LMS engagement increases students' mathematics success and online authentic learning self-efficacy (Uzunboylu et al., 2020), and students benefit from the incorporation of LMS to the educational process (Stasinakis & Kalogiannakis, 2015). Despite the critical acclaim of using LMS, Papadakis et al. (2018) argued that due limitations of mobile access, Moodle is used mainly as an electronic document repository than as an effective learning tool.

Studies conducted in the Philippines showed similar results. According to Taban's (2021) study from 2021, students satisfactorily perform when using LMS, which is evidenced by LMS's high usability. However, Taban (2021) noted that a weak or poor internet connection was the main obstacle to using LMS. Furthermore, the study by Magno (2017) revealed that students exposed to LMS have higher achievement in English, mathematics, science, and Filipino, significantly improving self-regulation, motivation, and engagement. With the pressing need to address the current issue of untaught topics in basic calculus due to congested curriculum; and the promising benefits of utilizing an LMS, the researcher is motivated to conduct the current study to test whether the use of courseware through Moodle LMS enhances the performance of the students on the least taught topics in basic calculus, specifically on limits. Moreover, since the onset of the COVID-19 pandemic, the academic institutions have been utilizing courseware through Moodle LMS. However, in the locality, no study has been conducted yet to test the effectiveness of implementing the said courseware. It is in this regard that the current study is proposed.

This study aimed to determine whether the use of courseware through Moodle LMS enhances the students' performance on the least taught topics in basic calculus, specifically on limits. The results from this study can be of use as a basis for basic calculus teachers as the curriculum implementers, curriculum designers, school administrators, department of education, and policymakers to consider the inclusion of LMS in academic institutions and to make necessary adjustments to present school rules and regulations, learning modalities, and learning procedures to enhance the learning process in mathematics. Moreover, the findings of the study will be used to design an action plan to capacitate mathematics teachers in utilizing and maximizing the usability of Moodle.

Innovation, Intervention, & Strategy

The researcher utilized the developed Moodle-based courseware package to enhance the student's performance on the least taught topics in basic calculus, specifically on limits. The respondents of this study were STEM students at a premier private university in Davao Region, Philippines. The intervention was employed over three weeks during the 2nd semester of the academic year 2022-2023.

The courseware package was designed and developed using Moodle LMS and following the Ignatian pedagogical paradigm (IPP), the educational paradigm followed by all Ignatian institutions worldwide. IPP is a teaching methodology that guarantees action as a manifestation of reflection following a particular experience (Bello, 2021). According to the International Commission on the Apostolate of Jesuit Education (ICAJE, 1993), IPP comprises five components, as seen in **Figure 1**.

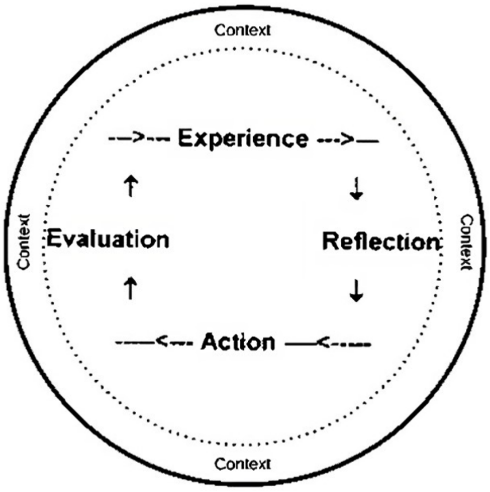

Figure 1. Five components of IPP (ICAJE, 1993)

Guided by IPP, the researcher designed courseware that is responsive to the need of the students. The developed courseware comprised an introduction tile, four topic tiles (one for each identified least taught topic), and two quiz tiles. Each tile was activity restricted so that the students could only access the tile contents of the succeeding tile if they had completed the activities of the previous tile.

The restriction was done so the students could keep up, where they had left off and ensure they had the required pre-requisite knowledge before proceeding to the next concept. **Figure 2** presents the overall courseware interface.

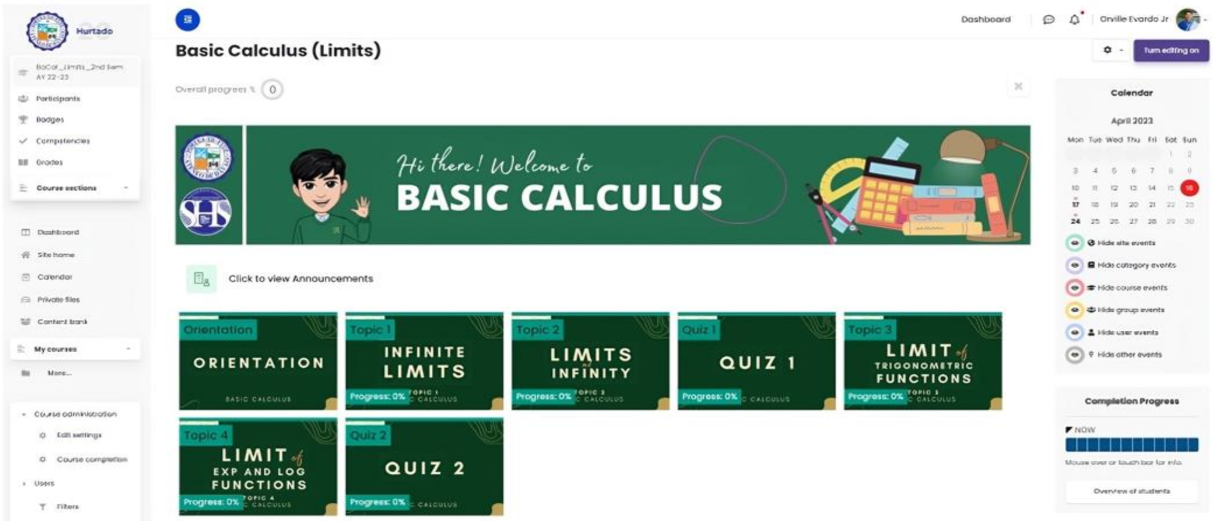

Figure 2. Courseware package interface (Source: Authors' own elaboration)

Each least taught topics have its corresponding topic tile, which features the following activities/contents:

(1) introduction,

(2) lesson activity,

(3) learning materials,

(4) drill, and

(5) forum activity.

Figure 3 shows the topic tile contents. **Figure 3** presents a sample topic tile content.

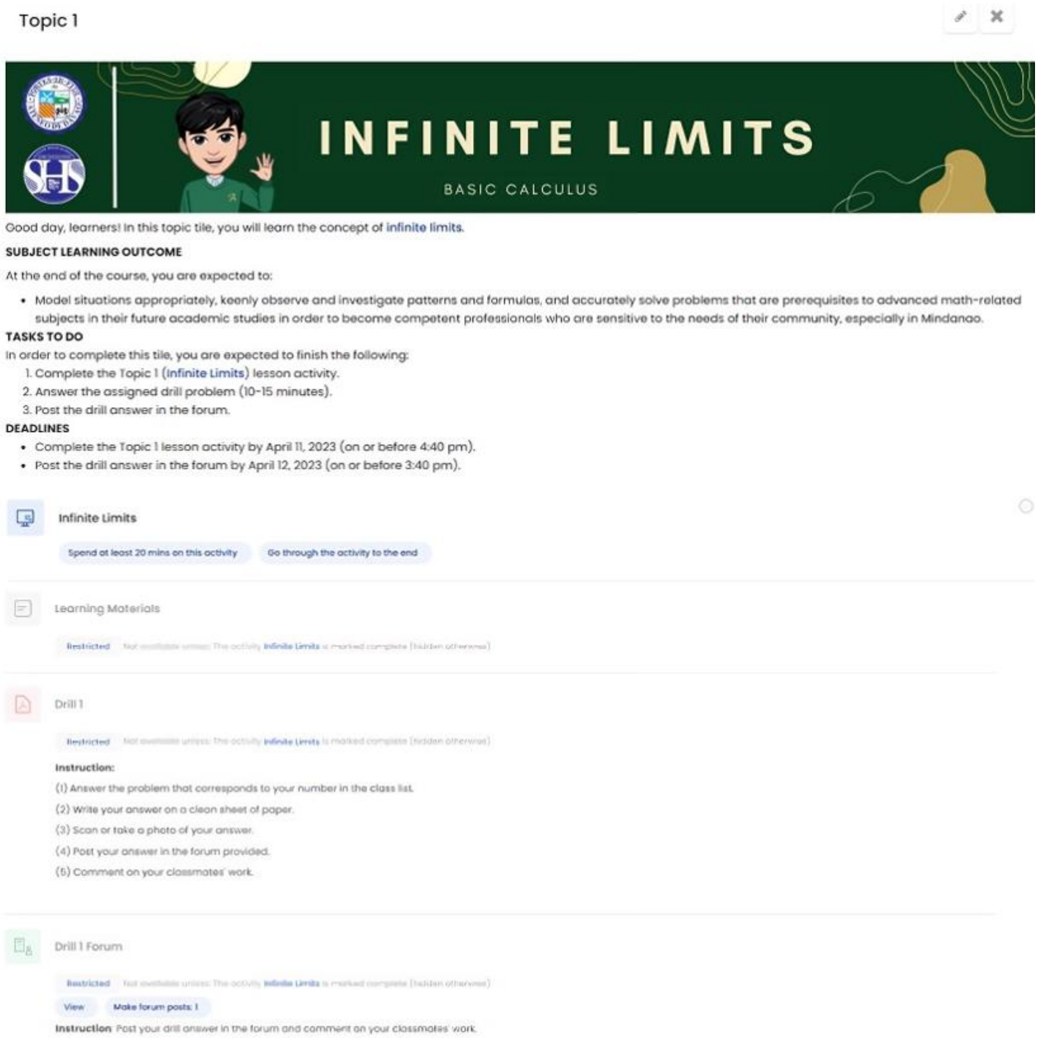

Figure 3. Topic tile contents (Source: Authors' own elaboration)

Introduction

The introduction featured subject learning outcome(s), tasks to do, and deadlines. The subject learning outcome(s) will prime the students on the course's overall objective. It informs the students of the expected competencies they should possess after completing the course. The tasks to do will tell the students of the expected activities they have to complete within the tile. The deadlines section will inform the students of the upcoming deadlines they must observe.

Lesson activity

The lesson activity is the highlight among the tile contents. This is the portion, where the content is being presented to the students. The lesson activity is designed to pattern the learning activities in IPP. The five elements of IPP are embedded in the lesson activity flow. **Figure 4** shows the lesson activity flow.

Figure 4. Lesson activity flow (Source: Authors' own elaboration)

Learning materials

The learning materials inside the lesson activity are also provided outside the lesson activity for accessibility. This is done so the students do not have to go through the lesson activity again to access the document(s).

Drill

After completing the lesson activity, a drill will be provided to test the students' level of understanding. Each student will be assigned to a unique problem to which they will solve. Drill answers will be posted in the forum.

Forum

This activity is provided to encourage online collaboration among students. The drill answers will be posted in the forum, which is visible to everyone. Students can comment, raise questions, or affirm each other's answers.

METHODOLOGY

Research Design

This research utilized the developmental research design, also known as R&D (Research and Development). Richey (1994) described developmental research as the systematic study of designing, developing, and assessing educational processes, products, and programs that must adhere to internal consistency and effectiveness standards.

Richey (1994) added that the most common types of developmental research include scenarios in which the product-development process is analyzed, reported, and assessed. R&D in educational research focuses on the advancement of product-oriented research in education and the enhancement of educational quality as it relates to the assessment program in the field of education (Gall et al., 1996).

This research design is appropriate for this study since the study's objective is to design and develop a Moodle-based courseware package for least taught topics in basic calculus to enhance the students' performance. The effectiveness of the courseware package will then be evaluated using proper statistical tests.

Participants & Sources of Data

This research used a nonprobability sampling method, specifically convenience sampling. Convenience sampling is a technique, where units are chosen for the sample based on their accessibility to the researcher. This may be due to proximity geographically, availability at a specific moment, or willingness to participate in the study (Nikolopoulou, 2022). A convenience sample includes individuals or groups most accessible to the researcher (McCombes, 2022). Appropriate sampling method is essential because it compels researchers to be alert to any sampling problems that may arise during the study process, enhancing the validity and reliability of the study findings (Kanaki & Kalogiannakis, 2023).

In this study, the participants were basic calculus teachers at a premier university in Davao Region, Philippines, selected academic administrators, and two intact heterogeneous classes from STEM strand. The selection of the intact classes involved in this study was based on the actual teaching load of the researcher. Seven basic calculus teachers, five academic administrators, and 69 students are involved in this study. Of the 69 students, 34 were in the experimental group, and 35 were in the control group. The selection of the experimental and control group was chosen at random. The experimental group was enrolled in Moodle-based courseware package after the pre-test. The experimental group was tasked to complete the set of activities asynchronously, while the control group was given lecture notes to study independently.

The study utilized the following inclusion criteria for the student-participants:

(1) the student-participant must be willing to participate in the study and must submit the parent's consent and student's assent form,

(2) the student-participant must have taken the pre-test,

(3) the student-participant must have completed the intervention, and

(4) the students-participant must have taken the post-test.

All students who did not meet the inclusion criteria were excluded from the study.

Data Analysis

The data gathered was summarized, analyzed, and interpreted using the following statistical tools:

Frequency count

To determine the least taught topics on basic calculus, specifically on limits, frequency count was used to summarize and present the result of the survey that was administered to basic calculus teachers. Moreover, frequency count was used to determine the common reasons why the identified topics were least taught. The data for the reasons will be presented using a word cloud.

Descriptive statistics

Mean (M) and standard deviation (SD) was used to determine the level of validity of the developed Moodle-based courseware package. The courseware package will be rated using a five-point Likert-type scale with five as "excellent" to one as "poor". **Table 1** presents the scale that was used to determine the level of validity of the developed courseware package.

Table 1. Level of validity, description, & interpretation

Scale	Mean range	Verbal description	Interpretation
5	4.20-5.00	Very high	The developed courseware package has a very high validity.
4	3.40-4.19	High	The developed courseware package has a high validity.
3	2.60-3.39	Moderate	The developed courseware package has a moderate validity.
2	1.80-2.29	Low	The developed courseware package has a low validity.
1	1.00-1.79	Very low	The developed courseware package has a very low validity.

Additionally, M, SD, skewness, and kurtosis were used to determine and describe the level of performance on the 30-item test results of the experimental and control group. **Table 2** shows the mean range with its corresponding proficiency scale using a base-40 computation, performance level, and interpretation.

Table 2. Post-test mean score, proficiency scale, performance level, & interpretation

Range of mean	Proficiency scale	Performance level	Interpretation
25.00-30.00	90.00% & above	Outstanding	Very high level of performance.
22.50-24.99	85.00%-89.99%	Very satisfactory	High level of performance.
20.00-22.49	80.00%-84.99%	Satisfactory	Moderate level of performance.
17.50-19.99	75.00%-79.99%	Fairly satisfactory	Low level of performance.
0.00-17.49	Below 75.00%	Did not meet expectations	Very low level of performance.

Normality & homogeneity tests

The normality and homogeneity test results were used to assess the appropriateness of running One-way analysis of covariance (ANCOVA) in the data analysis.

One-way analysis of covariance

One-way analysis of covariance (ANCOVA) at 0.05 level of significance was used to determine the significant difference between the post-test scores of the experimental and control group. The pre-test scores served as the covariate.

Ethical Considerations

The researchers established that the respondents' involvement is voluntary prior to data collection. The respondents who took part in this study were asked to sign a consent form as verification of their willingness to participate. The informed consent reflects the study's ethical aspects and were thoroughly discussed with respondents throughout the data collection process. Additionally, confidentiality is kept as a means of protecting respondents' privacy, building trust and relationship with study respondents, and maintaining ethical standards and the research process' integrity (Kaiser, 2009). The respondents were guaranteed that their identities would be kept completely confidential and would not be revealed throughout the data presentation or analysis. Lastly, transparency in research is a crucial ethical consideration for almost all social scientists (Moravcsik, 2019). The researcher was up front and honest about the study's goals and expected outcomes for the participant and the community. The researcher observed strict adherence to the study's methods. By adhering to the ethical standards, the researchers ensured that no harm were caused to the respondents during and after the study. The researchers make sure that the work environment, institutional characteristics, rules, regulations, and guidelines were all appropriately followed. As such, confidence in science was maintained both within the scientific community and in the relationship between science and society (Petousi & Sifaki, 2020).

RESULTS & DISCUSSION

Least Taught Topics in Basic Calculus

Least taught topics in basic calculus refer to the topics that most basic calculus was not able to cover over the course of their teaching the subject. **Figure 5** shows the least taught topics based on a survey conducted on seven basic calculus teachers.

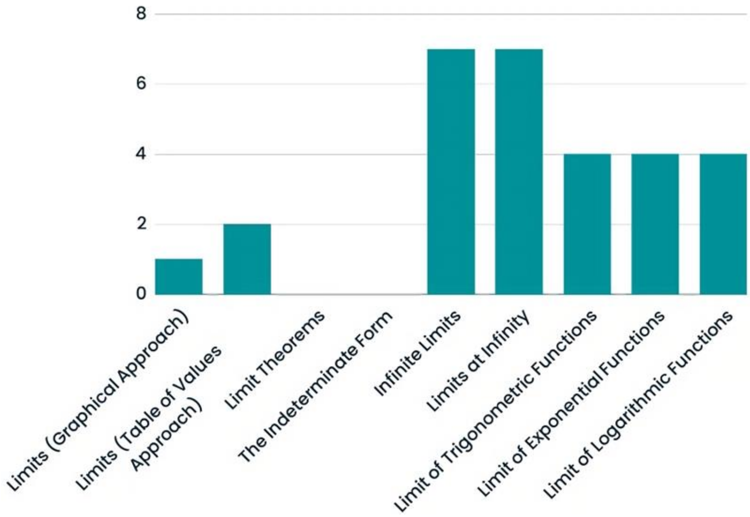

Figure 5. Least taught topics in basic calculus (limits) (Source: Authors' own elaboration)

Figure 5 shows an alarming statistic that the two topics in basic calculus under limits–infinite limits and limits at infinity–are the least taught topics, with seven out of seven teachers (100%) agreeing that they skip the said topics entirely. This was followed by the topics–limit of trigonometric functions, limit of exponential functions, and limit of logarithmic functions, which received four out of seven (57.14%) agreement from basic calculus teachers. Considering that limits serve as a foundation for calculus, it is concerning that a significant number of teachers are dismissing these topics. Moreover, since the mentioned topics garnered the majority of agreement from basic calculus teachers, the study's intervention will focus on these topics.

On the other hand, **Figure 5** suggests that specific calculus topics are considered fundamental or essential by the majority of basic calculus teachers. Specifically, the topics on limit theorems and indeterminate form were seen as essential by all the teachers, meaning they were unwilling to skip or overlook these topics in their teaching. In addition, the fact that limits (graphical approach) and limits (table of values approach) were also mentioned as important topics, albeit with lesser votes, one out of seven and two out of seven, respectively, indicates that these topics are likely to be covered by most calculus teachers as well. It also suggests that different approaches to teaching limits might be used by different teachers, with some preferring a graphical approach and others finding the table of values approach more effective.

Some of the more challenging mathematical concepts include the idea of infinity and transcendental functions. A teacher must be knowledgeable about several pedagogical approaches to make these topics more manageable for students to transfer learning to them appropriately. To teach these challenging topics equates to vast knowledge and practice of different strategies, which most teachers do not have time to learn because of other internal and external factors. Many studies showed significant improvement in students' performance in calculus by using nonconventional teaching strategies, which highlights the importance of mathematics teachers being able to implement varied teaching strategies in teaching calculus. Abdullah et al. (2020) on the use of experiential learning to develop the critical thinking of students in calculus Chen and Chen (2017) investigated the use of differentiated instruction in teaching calculus; Galia (2016) examined the use of a constructivist approach in teaching calculus; Hernandez et al. (2021) studied on the utilization of social media-based learning materials in basic calculus; and Jones (2015) explored dynamic reasoning as a tool in teaching limits at infinity and infinite limits.

Furthermore, the result of this study can be explained by the study of Kandeel (2017), which reported that students' common errors in solving limits of trigonometric functions include errors in remembering mathematical laws and theories connected to the topic; computational and procedural errors committed by students in their solution; and last are the conceptual and arithmetic errors. Teachers may see the topic as too difficult for students to learn, which may be a factor in not including it in this discussion. Moreover, Mamolo (2019) reported that the least learned topics in general mathematics are the topics on exponential and logarithmic functions, which were highly analytical.

Reasons for Least Taught Topics

Figure 6 shows the top five emerging themes of why some topics in basic calculus were least taught based on a survey conducted among seven basic calculus teachers. Basic calculus teachers were asked to provide their top three reasons why the topics:

(1) infinite limits,

(2) limits at infinity,

(3) limit of trigonometric functions,

(4) limit of exponential functions, and

(5) limit of logarithmic functions were not covered.

Figure 6. Reasons for least taught topics (Source: Authors' own elaboration)

The words' size indicates the theme's frequency based on the participants' responses. This indicates that a bigger word size means a higher frequency.

As seen in **Figure 6**, the leading reason why some topics in basic calculus are not covered is because of time constraints. The time available to teach basic calculus is limited, so mathematics teachers need to make a concerted effort to cover all the essential topics. The problem with this is that the choice of topics may vary from teacher to teacher, and some may prioritize certain topics over others. Teachers may feel that they need to prioritize topics that they deem to be more important or easier to understand, which can lead to omitting more challenging topics. This finding is parallel to that of Heller et al. (2012), Morton and Harmon (2011), and Zinger et al. (2020), which reported that teachers have frequently emphasized a lack of time as an issue in the classroom.

Moreover, it is concerning that due to time restrictions, teachers were unable to identify all mistakes and provide the appropriate feedback as needed (Mao & Crosthwaite, 2019). Since calculus topics are ladderized, understanding the previous topic is necessary to understand future topics, which could lead to severe problems. If student misconceptions were not corrected due to limited time, a chain reaction could make the subject unpleasant.

Students' capacity is also one of the significant considerations that teachers look into in teaching basic calculus. One of the struggles students faces when trying to understand limits is the abstraction of the concept. This abstraction can often lead to confusion or misunderstanding, especially for students who are used to dealing with concrete objects in their math classes. Another challenge that students face in understanding limits is the need for a strong foundation in algebra and trigonometry. Limits involve manipulating equations and expressions, and students must be comfortable with these subjects to be able to understand them. Without a strong foundation in these subjects, students may struggle to understand the underlying concepts of limits and how to apply them in calculus.

Basic calculus teachers also mentioned problems in terms of scheduling as one of the reasons why some topics are left untaught. Sudden changes in schedule due to national and local holidays (Gonzales, 2017), cancellation of classes due to natural disasters (Kuhfeld et al., 2020), school activities, and relevant other reasons hinders basic calculus teachers from teaching all of the subject content. On top of those reasons, teachers also have to consider the readiness of the students to proceed to the next lesson.

Another reason why teachers skip some topics is due to their level of difficulty. Some teachers might find these topics too challenging to teach effectively or believe their students will find them too difficult to understand. As such, some teachers may decide to skip these topics, fearing they may be unable to explain them adequately to their students. This result is corroborated by Gafoor and Kurukkan (2015), which found that 88.00% of the study participant hated mathematics because of the difficulty in understanding the subject matter and teacher or instructional-related factors.

Lastly, the relevance or relatability of a topic to real-life situations may also affect the teacher's decision to teach it. For instance, a teacher may emphasize topics such as derivatives and integrals over limits because they feel that the former topics are more relevant and directly apply to real-life scenarios. For the topics to be relevant to the students' daily lives, Simamora et al. (2018) emphasize the significance of including the students' cultural background. Students will be willing to study the topic once they realize its importance.

Level of Validity of Moodle-Based Courseware Package

Overall, Moodle-based courseware package has a very high validity with an overall mean of 4.75 (SD=.24), as shown in **Table 3**. Moodle-based courseware package garnered high validity in all four indicators: content validity, face validity, presentation and organization, and accuracy and up-to-datedness of information.

Table 3. Level of validity of Moodle-based courseware package

Indicators	Mean	Standard deviation	Verbal description
Content	4.70	.30	Very high
Face validity	4.72	.20	Very high
Presentation & organization	4.76	.29	Very high
Accuracy & up-to-datedness of information	4.83	.10	Very high
Overall	4.75	.24	Very high

In terms of content, the courseware package gained a mean of 4.70 (SD=.30), which has a verbal description of very high validity. This suggests that the content and instruction are concise, thorough, and developmentally appropriate. The result also suggests that the courseware package supports the growth of higher-order cognitive abilities like problem-solving, inquiry, creativity, critical thinking, and learning by doing. The result further implies that the students can comprehend and complete the set activities well without the teacher's supervision. This result parallels Bradley (2021), which asserts that using LMS creates an engaging environment, autonomy, enthusiasm, and motivation among students. Additionally, the result supports the e-learning theory (Mayer et al., 2015), which posits that effective instructional design principle includes student control and personalization.

Regarding face validity, the courseware package attained a mean of 4.72 (SD=.20) with a verbal description of very high validity. This indicates that the courseware package's font size and spaces are appropriate to the intended user and promote reading. This also directs that illustrations are simple, recognizable, and supplement the texts; the design and layout are simple, attractive, and pleasing. Tomita (2022) posits that no universal design guarantees positive experiences for every student because of diversity; however, according to Giasiranis and Sofos (2020), high completion rates and student motivation are influenced by high-quality instructional material, which is the outcome of effective instructional design. Moreover, the result conforms to the multimedia learning theory of Mayer (1997), which theorizes that students may learn more effectively from words and images than just words alone.

As for presentation and organization, it received a mean of 4.76 with an SD of .29, suggesting a very high validity. This result implies that the courseware's presentation is logical, engaging, interesting, and understandable. The result also implies that vocabulary is adapted to the reader's level of understanding and that the length of sentences and video materials is suited to the comprehension level of the readers. The result of this study is parallel to the study of Marasigan (2019), which suggests that instructional materials should be highly readable to contribute significantly to ease in comprehension of the contents of the material. In terms of accuracy and up-to-datedness of information, it attained the highest mean among the four indicators (M=4.83, SD=.10). This implies that, for the most part, the courseware package is free from conceptual, factual, grammatical, typographical, and computational errors and that the courseware package is free from obsolete information.

Overall, Moodle-based courseware package obtained a high validity rating from experts. This means that the courseware package can be used as a learning material, which is expected to increase the performance of students on least taught topics in basic calculus.

Level of Performance of Experimental & Control Groups

The quasi-experimental phase of the study involves two groups from two intact heterogeneous classes. There are 34 students in the experimental group, while the control group comprises 35 students. A pre-test was administered to assess the initial performance level of the two groups. **Table 4** shows the pre-test performance of the two groups.

Table 4. Descriptive statistics for pre-test scores of experimental & control group

Group	n	Mean	Standard deviation	Skewness	Kurtosis	Interpretation
Experimental	34	9.06	3.32	.177	-.625	Did not meet expectations
Control	35	8.51	3.11	1.623	3.884	Did not meet expectations

As shown in **Table 4**, the experimental group gained a mean of 9.06 (SD=3.32) while the control group had a mean of 8.51 (SD=3.11) in which both means were interpreted as did not meet expectations. This means that before the intervention, both groups do not have enough understanding of the topics at the start of the study.

Moreover, shown in **Table 4** are the skewness values for the experimental and control groups, .177 and 1.623, respectively. It can be noted that both values are positive, which means that the majority of the scores for both groups fall below the mean value.

To determine whether there is a significant statistical difference between the pre-test scores of the experimental and control group, an independent samples t-test with a .05 level of significance was administered. **Table 5** shows the result of the test for difference.

Table 5. Difference between pre-test scores of experimental & control group

Group	n	Mean	Standard deviation	df	t	p-value
Experimental	34	9.06	3.32	67	-.703	.484
Control	35	8.51	3.11			

Results indicate no significant difference between the pre-test mean scores of the experimental group (M=9.06, SD=3.32) and the control group (M=8.51, SD=3.11), $t(67)=-.703$, $p>0.05$. This suggests that before the intervention, the experimental and control groups have equal performance levels. Thus, it was accepted that the two groups were similar to each other in terms of their initial performance in basic calculus.

After the pre-test, the experimental group was enrolled in Moodle-based courseware package, while the control group was given lecture notes. The intervention lasted for three weeks covering four topics:

(1) infinite limits,

(2) limits at infinity,

(3) limit of trigonometric functions, and

(4) limits of exponential and logarithmic functions.

After the three-week intervention, a post-test was administered to assess the level of performance of the experimental and control group. Tabulated in **Table 6** are the salient post-test results.

Table 6. Descriptive statistics for post-test scores of experimental & control group

Group	n	Mean	Standard deviation	Skewness	Kurtosis	Interpretation
Experimental	34	22.47	3.38	-.714	.797	Satisfactory
Control	35	10.03	3.71	1.090	1.861	Did not meet expectations

Table 6 shows the post-test mean scores of the experimental group (M=22.47, SD=3.38) and the control group (M=10.03, SD=3.71). It can be noted from **Table 6** that the mean score for the experimental group was interpreted as satisfactory. In contrast, the control group's mean score was interpreted as not meeting expectations. Interestingly, the skewness value for the experimental group is negative, suggesting that most scores fall above the mean value. This implies that most of the students in the experimental group did better than an average student in the same group. On the other hand, the skewness for the control group shows a positive value, suggesting that most of the scores fall below the mean value.

To determine whether there is a significant statistical difference between the pre- and post-test mean scores of the experimental and control group, a t-test for dependent samples was conducted with a .05 level of significance. **Table 7** shows the salient results.

Table 7. Differences between pre- & postest mean scores of experimental & control groups

	Experimental		Control	
Group	Pre-test	Post-test	Pre-test	Post-test
n	34	34	35	35
Mean	9.06	22.47	8.51	10.02
Standard deviation	3.32	3.37	3.11	3.71
Gain score	13.41		1.51	
df	33		34	
t	-19.05		-3.21	
p-value	.000		.003	

Table 7 shows a significant difference between the experimental group's pre- and post-test mean scores, t(33)=-19.05, p<.05, with a gain score of 13.41. This implies that the courseware package effectively increases the students' performance on the least taught topics in basic calculus. Moreover, **Table 7** also shows a significant difference between the pre- and post-test mean scores of the control group, t(34)=-3.21, p<.05, with a gain score of 1.51. This implies that using lecture notes also effectively increases the students' performance on the least taught topics in basic calculus. Interestingly, although both methodologies effectively increase the students' performance, the gain score for the experimental group is greater than the gain score of the control group. This implies that students exposed to using Moodle-based courseware package gained more than the students who were given lecture notes.

The result of this study is similar to other studies, which reported a positive increase in students' performance by using Moodle-based instructional materials. Handayanto et al. (2018) reported that the increase in students' performance is associated with the students' interest in using Moodle. Mlotshwa et al. (2020) discovered that the functionalities within Moodle LMS were instrumental in improving conceptual understanding of mathematical functions. Similarly, Pahrudin et al. (2021) reported that Moodle-assisted e-learning influenced students' conceptual understanding and critical thinking skills.

Difference Between Level of Post-Test Performance of Experimental & Control Group

ANCOVA was conducted to determine a statistically significant difference between the post-test scores of the experimental group and control group while controlling for the pre-test scores as covariate. Normality and homogeneity tests were performed, and the assumptions were met. **Table 8** and **Table 9** present the result of the one-way ANCOVA.

Table 8. ANCOVA results for post-test scores with pre-test scores as covariate

Source	Sum of squares	df	Mean score	F	p-value	η^2
Pre-test	184.570	1	184.570	18.489	.000	.219
Groups	2,531.837	1	2,531.837	253.617	.000	.794
Error	658.872	66	9.983			
Total	3,513.246	68				

Table 9. Bonferroni pairwise comparison for adjusted marginal post-test mean

Group	n	Mean[a]	Standard error	Mean difference (I-J)	Standard error	p-value
Experimental (I)	34	22.328	.543	12.161	.764	.000
Control (J)	35	10.167	.535			

Table 8 suggests that there was a significant difference in the experimental group (M=22.328, standard error [SE]=.543) and control group (M=10.167, SE=.535) adjusted post-test scores while controlling for the pre-test scores, F(1,66)=253.617, p<0.05,

η^2=.794. This indicates that the two groups' performance levels after the intervention were not similar. To see which group benefited more from the intervention, **Table 9** shows the Bonferroni pairwise comparison, which reveals that the experimental group gained considerably more significant than those in the control group, with mean difference=12.161, $p<0.05$. When the effect size (η^2=.794) was evaluated according to Cohen (1988), it can be stated that Moodle-based courseware package used by the experimental group greatly affects the students' performance. The partial eta squared value shows that 79.00% of the variance in the post-test scores is explained by the groups (experimental or control) while controlling for the pre-test.

The result of this study indicates that adopting a Moodle-based courseware package has an advantage over simply giving students lecture notes in terms of improving student performance on the least-taught topics in basic calculus. This finding is supported by Shaame (2020), who discovered that students who received math instruction using a customized Moodle LMS outperformed those who received mathematics instruction through the more conventional chalk-and-talk teaching methods. Moodle alone proved to be an effective tool in increasing student performance. Moreover, according to Psycharis et al. (2013), using Moodle improved students' performance, which is associated with an increase in students' conceptual understanding. Many studies explored the use of Moodle combined with different teaching methodologies, which reported a positive impact on students. Kusuma et al. (2021) explored the effectiveness of project-based learning with Moodle combined. They reported that project-based learning with LMS Moodle positively impacts problem-solving skills and self-regulated learning. In addition, Husna and Sofnidar (2022) found that using the flipped classroom model along with information search techniques using Moodle-based media substantially impacts students' self-efficacy.

CONCLUSIONS & RECOMMENDATIONS

Based on the results of the study, the following conclusions were drawn:

(1) To effectively teach mathematics to their students, teachers must understand diverse pedagogies and instructional techniques. Every student has a unique learning style, so having a wide variety of teaching techniques is crucial.

(2) By adopting and implementing varied teaching pedagogies, teachers can help students develop critical thinking skills, problem-solving abilities, and a deeper understanding of complex mathematical concepts such as limits.

(3) Understanding different pedagogies and instructional methods helps teachers grow professionally. Effective classroom management is more prevalent among teachers who are lifelong students.

(4) Utilizing evidence-based techniques when integrating technology into instruction is one way to guarantee that the technology is both valid and relevant in education. Evidence-based practices make sure that technology is being used in a way that is successful for student learning and use data and research to inform instructional decisions.

(5) Educational practices, which yield higher student achievement is ideal. However, it is crucial to remember that various factors influence student achievement, including student background and motivation.

Moreover, based on the results, the following recommendations were made:

(1) Teachers may consider the use of Moodle and other LMSs to enhance the mathematics performance of students.

(2) Department of education may consider maximizing the use of its current LMS by institutionalizing the use of LMSs in every school.

(3) Department of education may consider trainings and professional development activities to capacitate teachers in using and maximizing the potential of LMSs in enhancing student learning.

(4) Further research may be done on a different setting to verify the results of this study.

(5) Further study may be done with more samples to amplify the generalizability of the study's findings.

Author contributions: Both authors have sufficiently contributed to the study and agreed with the results and conclusions.

Funding: No funding source is reported for this study.

Ethical statement: The authors stated that the study does not require any ethical approval. The study was conducted by the written approval of the study site's school principal. Written informed consents were obtained from the participants. Any personal information was kept confidential and any data that might be used to identify a person was anonymized.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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