LOADING SCHEME AND WORKED EXAMPLE STRATEGY IN LEARNERS' BASIC CALCULUS MASTERY

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Abstract

Grade 11 STEM (Science, Technology, Engineering, and Mathematics) learners encounter enduring challenges in achieving mastery of the different learning competencies of basic calculus specifically on antiderivatives and Riemann integrals, impeding their overall performance and interest in mathematics. This study focuses on investigating the efficacy of a loading scheme employing a worked example strategy to enhance learners' level of mastery. It used a quasi-experimental design wherein data were analyzed using mean percentage score and t-test. The study reveals that both the loading scheme employing a worked example strategy and conventional instructional approaches, encompassing lectures, demonstrations, and textbook usage, are effective in imparting knowledge of basic calculus to Grade 11 learners. The implementation of either approach significantly enhances the mastery levels of the learners in this challenging subject. However, noteworthy is the observation that conventional instructional approaches exhibit a higher effectiveness in teaching basic calculus compared to the loading scheme utilizing the worked example strategy. These findings suggest the importance of considering a blended instructional approach, incorporating the strengths of both methodologies, to optimize the teaching and learning experience in Grade 11 calculus education.

Keywords: antiderivatives and Riemann integrals, conventional strategies, lecture, demonstration, textbook

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Researcher

Context and Rationale

One of the most effective tools for the growth of a nation's overall aspects is mathematics. However, despite its recognized significance, a persistent challenge lies in ensuring that learners not only engage with mathematics but also develop a profound understanding, especially in intricate disciplines like calculus. The intricacies of basic calculus present a formidable hurdle for learners, often impeding their progress and impacting their overall mathematical proficiency. This challenge is multifaceted, as learners not only grapple with the abstract nature of calculus concepts but also face difficulties in applying these principles to real-world scenarios. Furthermore, variations in instructional methodologies contribute to the complexity, as conventional teaching approaches like lectures, demonstration, and the use of textbooks may not always align with diverse learning styles.

In different ways, all facets of human life are impacted by mathematics, according to Enu (2015). Studies by Tshabalala et al. (2018) and Umameh (2011) showed that mathematics is the cornerstone and a tool for any nation's growth in science, technology, and the economy. The general consensus among educators is that without a foundational understanding of mathematics, no one can advance in any field (Visser, 2015). Moreover, mathematics is used as the foundation for many sciences, such as physics, chemistry, and biology, as well as for non-science subjects like geography, art, music, economics, and even health and physical education. Due to its importance in preparing learners for their future careers in college, mathematics is a required core subject in secondary schools for all learners.

Geometry, algebra, trigonometry, number theory, and fundamental calculus are some of the fields of mathematics that fall under its umbrella. This study will focus on basic calculus. Calculus is a mathematical discipline that was developed to comprehend and describe interactions between two or more constantly changing objects (Davis & Hersh, 1981; as cited in Usman, 2012).

In Asia, mathematics is viewed as one of the most critical subjects wherein learners are encouraged to study the discipline (Leatham & Peterson, 2010; Ronis, 2008). It is in this view that in most Asian countries, guiding practices on children’s mathematics achievements are quite more vigorous (Wei & Dzeng, 2014).

Mathematics is taught as a general education subject in primary and higher education in the Philippines, and learners are expected to understand and appreciate its principles as they are applied to problem-solving, critical thinking, communicating, reasoning, making connections, representations, and decisions in everyday life while using the appropriate technology (K to 12 Basic Education Curriculum). Although the Senior High School (SHS) Science, Technology, Engineering, and Mathematics (STEM) specialized track now include a basic calculus course, learners are still expected to demonstrate an understanding of the fundamental concepts of limit and continuity of a function, the fundamental concepts of derivatives, and antiderivatives and Riemann Integral (K to 12 Senior High School Science, Technology, Engineering and Mathematics Specialized Subject, 2016). Furthermore, calculus is the foundation of mathematics training for all engineering courses, including those in the STEM strand, according to Sorby and Hamlin (2001). Calculus success is consequently crucial for STEM learners in senior high. Calculus offers the framework and mathematical background for further math courses (Willemse & Gainen, 1995).

The low achievement and lack of interest in mathematics (and STEM) among learners remain a problem in schools, colleges, and universities in developed and developing countries alike, despite the highly praised and acknowledged importance of mathematics and the fact that it is a prerequisite for most subjects (Chand, et al. 2021). However, despite the fact that calculus is important in a variety of fields, some learners find it difficult to understand it, which results in historically high failure rates (Usman, 2012). Several colleges throughout the world have noted the low success rate of calculus learners (Agustin & Agustin, 2009). The Trend International Mathematical Science Study Advanced (TIMMS), which looked at trends in learners' mathematical achievement, discovered that for more than 20 years, there had been some reductions in the learners' performances and no increases in the nations studied (Maltese & Tai, 2011). The UNESCO Center for Statistics reports that 617 million children and adolescents worldwide do not meet the basic competency requirements in reading and maths as of 2017. Locally, Filipino learners do well in classes requiring higher-order thinking skills but significantly worse in lessons requiring knowledge acquisition (Dinglasan & Patena, 2013; Ganal & Guiab, 2014).

Even in college, there are still issues with learning and comprehending mathematics (Americans, 2009; Presmeg, 2006). Additionally, a study conducted by Carbonel (2013) on the performance of the learners at Kalinga-Apayao State College during the second semester of 2013 found that the learners in Algebra had an "average performance" as shown by the computed mean of 2.15, with 50% of them falling under "average performance," 35% falling under "low performance," and only 15% falling under "high performance."

The performance of learners in national and international surveys on mathematics and science competence demonstrates this dismal state. We need to address several fundamental issues, such as retention and straightforward recall, in order to improve the system. However, the majority of schools and institutions did not achieve the passing rate specified by the National Educational Testing and Research Center (NETRC) in the most recent National Achievement Test results (Pagtulon-An and Tan, 2018).

Mathematics teachers constantly struggle to acquaint learners with the subject and reduce their difficulties. It is surprising that, in the most recent years of teaching in senior high school, a significant portion of Grade 11 learners do not maintain the entry-grade requirement for the STEM program. DO 55, s. 2016 states that learners should not have a math or science grade below 85%. Nonetheless, 11 learners (19.30%) in the class of 2020–2021 of Apayao Science High School received basic calculus grades that were less than 85%. In addition, 14 (21.54%) learners failed to achieve the required grade for the 2021–2022 school year. According to the learners, they were finding it extremely difficult to study integral calculus.

Teachers used a variety of useful ways to speed up learning to accommodate the significant percentage of learners who failed to get the required grade in mathematics. The teacher used diversified instruction, led tutorial and remedial sessions, made home visits, included technology in his teachings, offered enrichment activities, and retaught any lessons that the learners had trouble with. A teacher's ability to employ a variety of teaching strategies is one determinant in a learner's grade. Consequently, there is still a chance that learners will achieve the required minimum grade.

With these issues brought to light, this study focuses on evaluating the effectiveness of two strategies—using a loading scheme and worksheets with worked examples—on improving learners' level of mastery in basic calculus of STEM (Science, Technology, Engineering, and Mathematics) learners. Moreover, the possible results of this study may not only benefit mathematics teachers and learners but also curriculum planners and designers. Possible results may serve as their guide in planning a mathematics curriculum that would address and cater to the learners' diversity. Also, the expected findings of this study would serve as bases for planning mathematics faculty development programs and activities, and for formulating policies in mathematics education.

Similarly, this study can help ease the general difficulties teachers and learners have in every topic, in addition to offering fresh insights and suggestions for future research. As a result, education, which is important to a country's growth, will benefit. This supports the improvement of learners' learning abilities as well as the consideration of their mental health and growth of learning abilities.

Action Research Questions

This research determined the effectiveness of loading scheme in improving the mastery of learners in Basic Calculus in the 2nd semester fourth quarter specifically on antiderivatives and Riemann integral among Grade 11 STEM of Apayao Science High School. This study attempted to answer the following questions:

1. What is the level of mastery of the learners in the pre-test and post-test?

2. Is there a significant difference on the level of mastery between the pre-test and post-test of learners in the control and experimental group?

   Ho: There is no significant difference on the level of mastery between the pre-test and post-test of learners in the control and experimental group.

3. Is there a significant difference on the level of mastery in the pre-test and post-test of learners between the control and experimental group?

   Ho: There is no significant difference on the level of mastery in the pre-test and post-test of learners between the control and experimental group.

Innovation, Intervention, and Strategy

Loading Scheme: Sweller Cognitive Load Theory

The Sweller Cognitive Load Theory is the theoretical foundation for this study. The basic idea behind cognitive load theory is that because working memory capacity is constrained, learners may be overloaded with knowledge. If the complexity of their course materials is not adequately controlled, this will lead to a cognitive overload. This cognitive exhaustion hinders the development of new concepts, which ultimately lowers performance (Sweller, 1992).

Sweller's cognitive load theory has led to a number of instructional prescriptions. Teachers should carefully analyze the attention demands of instruction. When the learner has to focus on too many distinct things at once, processing problems occur. Additionally, he recommended the employment of a single, cohesive representation. They should enable the learner to concentrate rather than divide their concentration between two areas, such as a diagram and the text or even a diagram with labels that are not situated close to their referents. Eliminating redundancy is another suggestion made by Sweller. Learning has been demonstrated to suffer from redundant information between the text and the diagram. In addition, teachers should encourage systematic problem-space exploration as an alternative to conventional, repetitive practice. Provide animation and audio narration (and/or text descriptions) simultaneously during multimedia education as opposed to sequentially. Last but not least, teachers should offer worked examples in place of the typical problem-based instruction.

Sweller's instructional design model is predicated on the ideas that assimilation of numerous pieces of information at once is challenging due to our finite working memories. It is necessary to provide numerous information items at once when they interact. This imposes a heavy cognitive load upon the learner of the information and threatens successful learning. High levels of element "interactivity" and their resulting cognitive load can be inherent in the content, learning language grammar inherently involves more element interactivity than simple vocabulary learning.

However, weak methods of presentation and instruction may result in unnecessarily high overhead. An example would be to present a learner a figure whose understanding requires repeated consultation of the text. While the learner tries to understand the material, the additional work necessary to decode and translate the graphic competes with it for limited working memory resources.

According to Miller (2009), working memory has a limited capacity and can only handle roughly seven bits of information at once. Combining the senses to display information is one method that helps to marginally increase working memory capacity. If the working memory limit is reached, part or all of the information was lost during processing unless it is recorded permanently as it is being processed. The study of cognitive science is concerned with how people learn, remember, and solve problems. The term "cognitive load" refers to the total demand on working memory at any given time. Cognitive load theory was introduced by Miller's hypothesis that most people can hold onto seven "chunks" of information in working memory.

Moreover, Miller cited in Simon and Chase's (1973) research, where they studied expert and novice chess players, showed that when expert chess players were presented with a game configuration that could occur during a regular chess game for a few moments and the configuration was then removed, they could reconstruct the same game configuration much better than novice chess players.

However, when a configuration did not come from an actual chess game, expert and novice chess players showed no difference in their ability to reconstruct the game configurations. Just like the chess experts, problem-solving experts have an immense knowledge of problem situations and have constructed many mathematical schema, or "a cognitive structure that specifies both the category to which a problem belongs and the most appropriate moves for problems of that category" to activate when needed. John Sweller (1988) developed cognitive load theory while studying problem-solving and has defined it to state that 'optimum learning occurs in humans when one minimizes the load on working memory which in turn facilitates changes in long term memory'.

Worked Example Strategy

A worked example consists essentially of a problem statement and the presentation of a knowledgeable solution. Working examples are helpful for explaining processes and addressing problems. According to Payne, et al (2017), using worked examples when teaching beginner learners improves learning effectiveness. Working examples even help to cut down on the quantity of practice problems required. The thinking and practices of an expert are made clear to the learner through worked examples. Worked examples, according to cognitive theory, lessen cognitive stress. Rather than using limited working memory to search for a solution, learners can focus on learning the moves that are important for solving a problem. Worked examples can keep learners from resorting to a trial-and-error approach. With a trial-and-error approach, a learner may even arrive at a solution without having learned effective approaches to the problem.

According to Carrol (1992), there are three reasons why worked examples be a useful instructional tool. First, worked examples may greater encourage mental participation on the part of the learner. Less time may be spent on lecture and demonstration of procedures and more time on productive problem solving. Second, during conventional practice, a limited number of examples are presented, allowing learners to make faulty inductions and construct incorrect procedures. Explicit examples may help to constrain errors during this practice time, when much of the learner's meaning for mathematics is constructed. Lastly, many learners have no one at home to assist them with high school mathematics. By the time they begin working at home, decay in learning has taken place, leaving learners who already have gaps in their mathematical knowledge unable to solve the homework problems. Worked examples should serve as an extension of the teacher, providing scaffolding during practice at home and in class.

Application of Loading Scheme and Worked Example

Theory and practice are integrated by an excellent math teacher through reflection. To analyze learning conditions and enhance classroom instruction, teaching and learning theories offer frameworks. In a similar manner, the ideal educator for an interactive curriculum is not a strict mentor but a dependable facilitator of knowledge. He helps learners progressively get rid of the habit to depend on others rather than being someone they always rely on. He encourages learners to become active creators of knowledge rather than passive consumers of information, teaches them how to analyze, characterize, and discuss problems rather than just teaching them the answers but also how to come up with or come across sound solutions on their own. In order to complete the task independently and experience true democracy, where everyone have rights as well as obligations, it is important for learners to understand how to do things rather than just what to do (Education Post Vol. XVIII No. 6).

Moreover, both the teachers themselves and the methods of instruction are crucial to the success of the learners. For learners to demonstrate competence and mastery, teachers must be skilled in implementing a variety of strategies that will appeal to diverse learners.

Mathematical proficiency is a core human-resource competency that should be strengthened to stay competitive. Furthermore, there is a need to assess the level of mastery of the learners to identify the strengths and weaknesses in a subject area, specifically Mathematics, that needs improvement and enrichment.

This study would like to contribute to the improvement of mathematics teaching and learning, especially in secondary mathematics education. The identified learning levels of learners in mathematics could develop the teachers' awareness and deeper understanding of how learners could learn best. Knowledge about the diversity of learners would help teachers improve their mode of delivery and assessment in the classroom. Improvement in the teachers would occur, in the sense that they would be attending to the different needs of the learners, giving them chances to vary their teaching styles. Hopefully, this study would challenge the teachers to try and use a variety of teaching techniques and strategies to meet the needs of their learners. In addition, a clear understanding of the diversity of the learners would increase the teachers' patience in adjusting to the learners' needs, efficiency in the teaching-learning process, self-reliance, and self-improvement, thereby minimizing teaching-learning problems. A clear understanding of the teaching styles that affect mathematics learning of the learners may provide the teachers and all concerned with the information needed to work out plans towards making learners more responsible for mathematics learning.

Figure 1 shows the paradigm of the study. The figure illustrates how this study was conducted by the researcher. This model provides a guide for a better way of understanding the given problem.

The first part of the figure is the pre-experimentation. This includes the construction of the teacher – made proficiency test. The pre-test is aligned to the Most Essential Learning Competencies (MELCs) in antiderivatives and Riemann integral of Basic Calculus for the fourth quarter.

The learners and the study's subject were the STEM Grade 11 learners from Apayao Science High School who participate the pre-test before the experimental. Learners in the average experimental group and control group will complete the same pre-test, whereas the experimental group's below-average and above-average learners will complete separate pre-tests. The 11th grade class is divided into two groups; section A will serve as the experimental group and section B as the control group. There is a wide range of learners in each class. Random selection was used to make the selection. The learners in the experimental group was divided into three groups according to the scheme of below average, average, and the above average group.

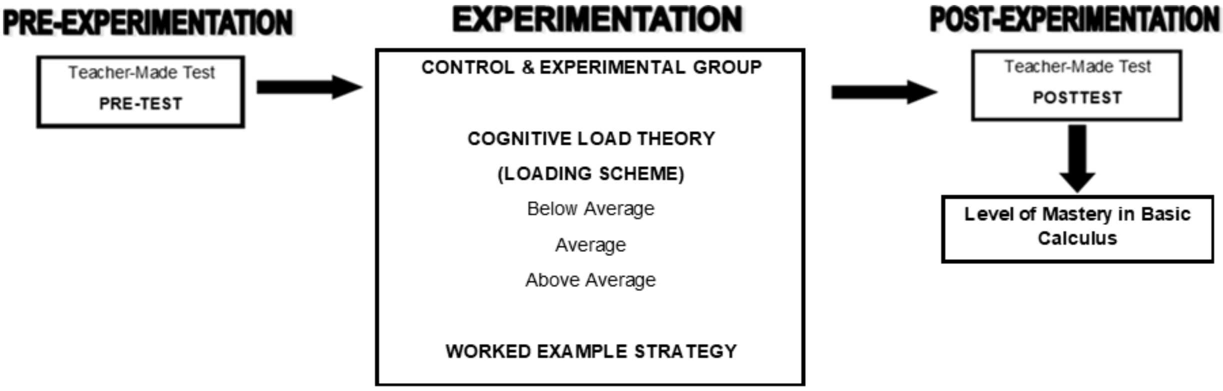
During the experimentation, the Cognitive Load Theory approach and worked example strategy was utilized. The experimentation part will start at the first week up to the 8^{th} week of Quarter 4 for the school year 2022-2023. The use of worked-example strategy was given every week to the experimental group while the control group was taught using the conventional method. The learners in the experimental group will answer the worksheet after the class discussion.

The main concept of the study is pointed towards the effect of the loading scheme to teaching-learning process. This study is further based on the concept of Cognitive Load Theory, specifically the worked example strategy that will make a big difference in the level of mastery of the learners.

After the conduct of the study, the researcher will construct the post-test that is still aligned with the MELCs. Learners in the experimental group and control group will answer the same posttest. With the help of the loading scheme and worked example strategy, instruction will facilitate learning thereby producing a positive outcome, which is a high level of mastery in Basic Calculus.

Figure 1

Conceptual Framework



Action Research Methods

Research Design

Quasi-Experimental with two groups pretest-posttest design (Thyer, 2012) was utilized in this research. This design has a control group and experimental group. Both group of participants were given pretest before exposing the experimental group to a treatment. Pretest sets the baseline level of mastery of the learners. It measures the stock knowledge of the learners in the topic. The lessons were delivered right after the pretest.

The goal of quasi-experimental research is to test cause and effect by observing how subjects react to phenomena. It also aims to evaluate interventions and demonstrates causality between an intervention and an outcome.

Participants and/or other Sources of Data and Information

Grade 11 learners of Apayao Science High School for school year 2022-2023 were the participants of the study. A total of 48 learners were counted using complete enumeration. Section A, which have 23 learners, serves as the experimental group, while Section B, which have 25 learners, serves as the control group. The control group consist of 12 males and 13 females, whereas 12 males and 11 females compose the experimental group.

The experimental group was categorized using their Pre-Calculus final grade, which is a requirement for Basic Calculus, according to the loading scheme of below average, average, and above average. The learners' loading scheme was determined by percentile ranking. Percentile rank scores enable comparisons between learners and their peer group, according to Longsdon (2022). The percentile rank of a learner indicates whether their score was on par with or higher than that of the norm group's percentage of learners. Percentile 25 and below was classified as below average, 26^{th} to 75^{th} percentile belongs to average group, and 76^{th} and above belongs to the above average group.

After calculating the learner's percentile score, those who received a final grade of 85% or below was considered below average. While learners with final marks between 86% and 88% was considered average, those with scores of 89% or higher was considered above average. Here is a breakdown of the participants' distribution within the experimental group:

Table 1

Distribution of Participants under the Experimental Group

Loading Scheme	**Percentile Rank**	**Grade in Pre-Calculus**	**Frequency**		**Total**
			Male	**Female**	
Below Average	P_{25} and below	85% and below	3	3	6
Average	P_{26} to P_{75}	86% to 88%	6	5	11
Above Average	P_{75} and above	89% and above	3	3	6
		Total	12	11	23

Data Gathering Methods

The pretest and posttest, learning plan, and the worksheets were used in the study. The Teacher-Made Proficiency Test (TPT) covered the different learning competencies of Basic Calculus for the fourth quarter. These are the learning competencies included in the Most Essential Learning Competencies (MELCs) in antiderivatives and Riemann integral of the Department of Education. The MELCs are: illustrate an antiderivative of a function; compute the general antiderivative of polynomial, radical, exponential, and trigonometric functions; compute the antiderivative of a function using substitution rule; solve problems involving antidifferentiation; solve situational problems involving exponential growth and decay; illustrate the definite integral as the limit of the Riemann sums; illustrate the Fundamental Theorem of Calculus; compute the definite integral of a function using the Fundamental Theorem of Calculus; compute the definite integral of a function using the substitution rule; compute the area of a plane region using the definite integral; and solve problems involving areas of plane regions.

The participants' pre-test and post-test were both conducted using the TPT. The TPT was checked and validated by School Learning Resources Committee. To create a good test, the researcher improves and raises the level of questioning for the post-test using the same learning competencies provided in the pre-test.

The primary data collection tools were the teacher-made pretest and posttest, each of which has 40 items. It was be applied to compare learner level of mastery before and after the intervention. Before being employed in the actual study's conduct, the aforementioned tests were prepared and their content evaluated. Since the multiple-choice test is the most adaptable and efficient way to measure academic accomplishment, it was employed.

Worked-Example Worksheets were prepared by the researcher and it was content validated and evaluated by the members of the School Quality Assurance and approved by the school head. The worksheets were aligned to the MELC and the distribution of MELCs per week is shown below:

Week No.	Most Essential Learning Competencies in Antiderivatives and Riemann Integral
1	*Compute the general antiderivative of algebraic functions.*
2	*Compute the antiderivative of algebraic functions using substitution rule.*
3	*Compute the antiderivative of exponential, logarithmic and trigonometric functions using substitution rule.*
4	*Solve problems involving antidifferentiation.* *Solve situational problems involving exponential growth and decay.*
5	*Illustrate the definite integral as the limit of the Riemann sums.*
6	*Illustrate the Fundamental Theorem of Calculus.* *Compute the definite integral of a function using the Fundamental Theorem of Calculus.*
7	*Compute the definite integral of a function using the substitution rule.*
8	*Compute the area of a plane region using the definite integral.* *Solve problems involving areas of plane regions.*

Some documents were analyzed in order to gather data pertinent to the research. The final grade in Pre-Calculus of the 48 learners were used in the study which was taken from their permanent record or Form 137. The researcher conducted an interview with the learners to clarify their answers that were elicited from the accomplished test. Informal observations were also conducted to supplement the data that were gathered in the study.

Pre-test was given to the learners before the experimentation. And the results of their pre-test were analyzed to determine the mastery level at the beginning of the experimentation. The researcher prepared the learning plan and the worksheets in conformity with the worked-example design. Different types of activities were prepared based on the loading scheme. The experimentation was conducted on the fourth quarter of the school year 2022-2023 in as much as the researcher followed the most essential learning competencies and budget of work. After the experimentation, the researcher administered the post-test following the same procedure with that of the pre-test. And the results were subjected for analysis to find out if there was significant difference after the experimentation.

Data Analysis

The researcher used the Mean Percentage Score (MPS) to identify the level of mastery of the learners in the pre-test and posttest. The percentage distribution that was broken down into seven scales to distinguish the level of mastery following indicators, which were taken from the recommendations made by DepEd NETRC, was used to calculate and define the percentage of mastery of the learning competencies (Table 2).

The significant difference on the level of mastery between the pre-test and post-test of learners in the control and experimental group was analyze using paired t-test. Moreover, independent t-test was also used to determine the significant difference on the level of mastery in the pre-test and post-test of learners between the control and experimental group.

Table 2

Scale for Interpreting Learners' Level of Mastery

Mean Percentage Score	Descriptive Equivalent	Description
96% - 100%	Mastered	Exceeded the core requirements in terms of knowledge, skills and understanding of the Most Essential Leaning Competencies in antiderivatives and Riemann integral and the learner can work independently without guidance from the teacher.
86% - 95%	Closely Approximating Mastery	Almost all the knowledge, skills and understanding of the Most Essential Leaning Competencies in antiderivatives and Riemann integral is closely mastered and the learner needs minimal guidance from the teacher.
66% - 85%	Moving Towards Mastery	Developed the fundamental knowledge, skills and understanding of the Most Essential Leaning Competencies in antiderivatives and Riemann integral and the learner needs guidance from the teacher during the guided/ processing activities of the lesson.
35% - 65%	Average Mastery	Possessed the minimum knowledge, skills, and understanding of the Most Essential Leaning Competencies in antiderivatives and Riemann integral but needs help from the teacher throughout the duration of the lesson and the learner needs guidance from the teacher throughout the duration of the lesson.
15% - 34%	Low Mastery	Struggled with understanding the skills and fundamental knowledge of the Most Essential Leaning Competencies in antiderivatives and Riemann integral and the learner needs additional learning materials from the teacher.
5% - 14%	Very Low Mastery	Struggled with understanding the skills and fundamental knowledge of the Most Essential Leaning Competencies in antiderivatives and Riemann integral and the learner needs remediation lesson from the teacher.
0% - 4%	Absolutely No Mastery	Struggled with all the skills and fundamental knowledge of the Most Essential Leaning Competencies in antiderivatives and Riemann integral and the learner needs to be re-taught of the lesson.

Ethical Issues

The secondary learners, specifically the Grade 11 learners, who were under the care of ethics and the subject of the learning process, were the main focus of this study. By abiding by moral principles while carrying out this research, the researcher ensured their safety, offered total security, and respected their confidence.

In implementing the study, the researcher made certain that participation was entirely voluntary. Participants who refused to take an interest faced no punishment or loss of benefits to which they were typically entitled. Participants were free to withdraw their consent and stop participating at any time. All personal information, including the participants' names, was kept confidential to preserve the privacy of the data and conclusions, as well as their safety.

To further guarantee that the participants were given complete information and deliberation about the research, letters of informed consent and informed assent were presented and signed by participants and parents. To address the vulnerability of the minor participants, parental informed consent was also made available to the participants' parents or legal guardians. The choice made by the parent or legal guardian was likewise optional. In accordance with RA 10173, generally known as the Data Privacy Act of 2012, this study followed its mandates to prioritize sensitive personal information, such as an individual's race, ethnic origin, age, color, and other characteristics, ensuring that the person under study was properly protected.

Throughout the study, the researcher refrained from using derogatory, discriminating, or other unfavorable language. Rest assured that participants in this study retained a positive attitude toward the significant contributions they made.

Finally, in order to support the truth and prevent inaccuracy, plagiarism, fabrication, falsification, or misrepresentation of study data was avoided. During the course of this investigation, the researcher followed ethical best practices and relied on solid scientific methods to guarantee that research participants were not injured or had their perspectives altered.

Discussion of Results and Reflection

Level of Mastery of the Learners

The participants' performance on the pre-post exams that were given to them before and after the study's completion was used to determine the participants' level of mastery. The scores of learners were converted into percentages, which ultimately indicated their level of mastery. The results of the pre-posttest for the control and experimental groups' levels of mastery are shown in Tables 3, along with a description of each level's mastery.

The level of mastery of the learners in the control group in the pretest is “low mastery” with 27.50% Mean Percentage Score (MPS) which means that the learner struggled with understanding the skills and fundamental knowledge of the Most Essential Leaning Competencies in antiderivatives and Riemann integral and the learner needs additional learning materials from the teacher. However, in the post-test the MPS increased to 82% characterized as the level of “moving towards mastery” wherein the learners have already developed the fundamental knowledge, skills, and understanding of the Most Essential Leaning Competencies in antiderivatives and Riemann Integral but the learner still needs guidance from the teacher during the guided/ processing activities of the lesson.

Similarly, in the experimental group, the learners’ level of mastery in the pretest is “low mastery” as indicated by the 27.93% MPS that also increased to 77.07% MPS in the post-test described to be in the level of “moving towards mastery”. The mastery of the learners improved after the conventional way of teaching like lectures, demonstration, and the use of textbooks for the control group; and the application of the loading scheme utilizing worked example strategy in the experimental group. This was also evident from their scores in the worksheets. The difference is that it was observed that in the experimental group, the learners were more focused on accomplishing their worksheets which were developed based on their cognitive level. The learners were observed to be more motivated to do the worksheet compared to the learners in the control group. The findings implicate that the utilization of the lecture, demonstration and textbook method of teaching, alongside a loading scheme incorporating work example worksheets, has proven to be effective in instructing Grade 11 learners on the concepts of antiderivatives and Riemann integral. The conventional approach of delivering information through lectures and demonstration, supplemented by textbook resources, has successfully conveyed the required mathematical concepts to Grade 11 learners. Simultaneously, the structured loading scheme, combined with practical engagement through work example worksheets, has also demonstrated efficacy in facilitating understanding and mastery of antiderivatives and Riemann integral.

Research findings affirm the effectiveness of the loading scheme when employing the worked-example strategy. Noceto's (2018) study, for instance, demonstrated that the loading scheme successfully elevated the competency level of second-year learners in mathematics. Furthermore, research conducted by Chen, O. et al. (2020) and Maryati, W. E. et al. (2020) indicated that worked examples have proven to be supportive in the development of mathematical schema and have enhanced the transfer of problem-solving skills. Additionally, Treffers (2019) underscored the importance of presenting problems alongside their solutions, identifying effective example characteristics, and recognizing learners' activities.

Conversely, conventional teaching methods like lectures, demonstrations, and textbooks also show efficacy in mathematics education. Wang's (2022) study indicates that both conventional and contemporary methods contribute to improving learners' knowledge levels. Estorninos et al. (2020) highlighted the positive impact of the lecture method on academic performance, especially in aiding learners facing difficulties. Onyeka and Okoye (2023) observed a positive effect on math achievement through the demonstration method. Ding and Carlson's (2013) research emphasized the influence of Chinese teachers adhering to a "textbook-centered" approach on the learning outcomes of Chinese math learners.

Table 3

Level of Mastery of the Learners

Control Group					Experimental Group				
Learner	Pretest		Posttest		Learner	Pretest		Posttest	
	MPS (%)	Description	MPS (%)	Description		MPS (%)	Description	MPS (%)	Description
A	22.5	Low Mastery	95	Closely Approximating Mastery	1	30	Low Mastery	85	Moving Towards Mastery
B	30	Low Mastery	90	Closely Approximating Mastery	2	27.5	Low Mastery	72.5	Moving Towards Mastery
C	25	Low Mastery	72.5	Moving Towards Mastery	3	32.5	Low Mastery	80	Moving Towards Mastery
D	32.5	Low Mastery	80	Moving Towards Mastery	4	20	Low Mastery	82.5	Moving Towards Mastery
E	25	Low Mastery	87.5	Closely Approximating Mastery	5	27.5	Low Mastery	82.5	Moving Towards Mastery
F	22.5	Low Mastery	90	Closely Approximating Mastery	6	27.5	Low Mastery	72.5	Moving Towards Mastery
G	27.5	Low Mastery	75	Moving Towards Mastery	7	27.5	Low Mastery	65	Average Mastery
H	22.5	Low Mastery	87.5	Closely Approximating Mastery	8	32.5	Low Mastery	80	Moving Towards Mastery
I	45	Average Mastery	90	Closely Approximating Mastery	9	17.5	Low Mastery	72.5	Moving Towards Mastery
J	27.5	Low Mastery	75	Moving Towards Mastery	10	32.5	Low Mastery	82.5	Moving Towards Mastery
K	35	Average Mastery	70	Moving Towards Mastery	11	40	Average Mastery	75	Moving Towards Mastery
L	20	Low Mastery	67.5	Moving Towards Mastery	12	27.5	Low Mastery	82.5	Moving Towards Mastery
M	20	Low Mastery	87.5	Closely Approximating Mastery	13	25	Low Mastery	75	Moving Towards Mastery
N	27.5	Low Mastery	57.5	Average Mastery	14	22.5	Low Mastery	77.5	Moving Towards Mastery
O	27.5	Low Mastery	95	Closely Approximating Mastery	15	35	Average Mastery	77.5	Moving Towards Mastery
P	30	Low Mastery	85	Moving Towards Mastery	16	22.5	Low Mastery	82.5	Moving Towards Mastery
Q	22.5	Low Mastery	90	Closely Approximating Mastery	17	20	Low Mastery	77.5	Moving Towards Mastery
R	32.5	Low Mastery	82.5	Moving Towards Mastery	18	40	Average Mastery	75	Moving Towards Mastery
S	37.5	Average Mastery	77.5	Moving Towards Mastery	19	32.5	Low Mastery	75	Moving Towards Mastery
T	22.5	Low Mastery	80	Moving Towards Mastery	20	25	Low Mastery	82.5	Moving Towards Mastery
U	32.5	Low Mastery	77.5	Moving Towards Mastery	21	22.5	Low Mastery	75	Moving Towards Mastery
V	15	Low Mastery	77.5	Moving Towards Mastery	22	32.5	Low Mastery	75	Moving Towards Mastery
W	30	Low Mastery	87.5	Closely Approximating Mastery	23	22.5	Low Mastery	67.5	Moving Towards Mastery
X	22.5	Low Mastery	90	Closely Approximating Mastery					
Y	32.5	Low Mastery	82.5	Moving Towards Mastery					
Mean	**27.50**	**Low Mastery**	**82.00**	**Moving Towards Mastery**	**Mean**	**27.93**	**Low Mastery**	**77.07**	**Moving Towards Mastery**

Difference between the Pre-test and Post-test of Learners

Table 4 presents a comparison between the level of mastery on the pre-test and post-test of learners in the control and experimental groups. The t-test results for the control group and the experimental group are -23.929 and -21.005, respectively, both with a two-tailed p-value of 0.000, leading to the rejection of the null hypothesis. Thus, there is a significant difference in the level of mastery between the pre-test and post-test of learners in both the control and experimental groups.

The significant improvement in mastery levels highlights the efficacy of both conventional teaching methods, such as lectures, demonstrations, and textbook usage, and the loading scheme utilizing the worked-example strategy. The notable impact on participants' scores suggests that these approaches positively contribute to the learning experience. Importantly, regardless of the chosen instructional strategy—whether conventional or employing the worked-example strategy—there are consistent and positive results. The effectiveness of conventional methods, such as lectures and demonstrations, may be attributed to their capacity to provide a structured and comprehensive overview of the subject matter. On the other hand, the worked-example strategy in the loading scheme is likely fostering active engagement and problem-solving skills, leading to a deeper understanding of the material.

The observed improvement in mastery levels signifies the positive impact of both sets of teaching methods employed in the study. This implies that both conventional and loading scheme strategy have significantly enhanced the learning experience, manifesting in noteworthy improvements in the level of mastery from the pre-test to the post-test.

However, there are researches argued that an innovative strategy is more effective over conventional methods of instruction. According to Ali, R. et. al. (2010), there was a noticeable difference in the academic accomplishment of learners who were taught using the conventional technique and those who used the problem-solving method and it was discovered that children who were taught problem-solving techniques had higher academic accomplishment than those who received conventional instruction. Additionally, the research by Hwa (2018) supports the claim that learning mathematics through digital games is more efficient than learning mathematics in conventional or traditional classroom conditions. And lastly, a study conducted by Cabrera (2017) also demonstrates that an innovative strategy such as outcome-based education is more effective than conventional method.

Table 4

Significant Difference on the Level of Mastery on the Pre-Test and Post-Test of Learners in the Control and Experimental Group

Group		Mean	t-value	p-value	Decision at 0.05
Control	Pre-Test	11	-23.929	0.000	Reject Ho (Significant)
	Posttest	32.80			
Experimental	Pre-Test	11.17	-21.005	0.000	Reject Ho (Significant)
	Posttest	30.83			

Difference between the Control and Experimental Group

The test for the significant difference on the level of mastery on the pre-test and posttest between the controlled and experimental is reflected in Table 5. In the pre-test, the t-test result is -0.238 with a p-value of 0.813. This leads to the decision of failing to reject the null hypothesis, indicating that there is no significant difference in the level of mastery between the two groups at the pre-test stage. This means that the level of mastery of the learners in two groups is generally equal.

The absence of a significant difference in the level of mastery between the two groups at the pre-test stage can be primarily attributed to the shared lack of prior knowledge or familiarity with the content being assessed. In situations where learners have little to no exposure or understanding of the material covered in the pre-test, their initial performances are likely to converge. This lack of prior knowledge acts as a common denominator, creating a baseline where both groups start with similar levels of unfamiliarity.

This is in line with the study of Oktaviyanthi, R., & Supriani, Y. (2015) which involves an experimental group and a control group, and it aims to assess the impact of Microsoft mathematics in teaching and learning calculus on learners' mathematics learning outcome.

The study found out that there are no significant differences from two groups in pretest results.

On the other hand, in the post-test, the t-test results show a t-value of 2.279 with a p-value of 0.027. In this case, the null hypothesis is rejected, suggesting a significant difference in the level of mastery between the control and experimental groups at the post-test stage. This means that the mastery levels of the two groups are not equal.

The disparity in post-test mastery levels between the control group, instructed through conventional strategies (lectures, demonstrations, and textbook usage), and the experimental group, exposed to the loading scheme utilizing worked-example strategy, suggests that the choice of instructional methods plays a crucial role in influencing learning outcomes. The control group, receiving instruction through conventional means such as lectures and demonstrations supplemented by textbook usage, may have found these familiar methods to be more effective for assimilating and mastering the material. The conventional strategies employed in the control group might have provided a structured and comprehensible framework, facilitating a better understanding of the subject matter. On the other hand, the loading scheme, while acknowledged as effective, might not have resonated as strongly with the experimental group. The unique features of the loading scheme may have introduced a level of complexity or novelty that influenced the experimental group's mastery levels differently than the control group. Factors such as individual learning preferences, prior experiences, and the adaptability of each group to the respective instructional approaches could have contributed to the observed differences in performance.

This finding emphasizes the significance of instructional design and pedagogical methods in educational settings. It suggests that, in certain contexts, conventional instructional approaches like lectures, demonstrations, and textbook usage may be more conducive to achieving higher levels of mastery.

Similar result has been found by other researchers like Cordero, J. M., & Gil-Izquierdo, M. (2018) who found out that conventional teaching methods have a positive influence on learners' proficiency in mathematics, while the implementation of more innovative active learning strategies seem to have a fewer impact on learner achievement.

Table 5

Significant Difference on the Level of Mastery in the Pre-Test and Post-Test Between Control and Experimental Group

Group		Mean	t-value	p-value	Decision at 0.05
Pre-test	Controlled	11	-0.238	0.813	Fail to reject Ho (Not Significant)
	Experimental	11.17			
Post-test	Controlled	32.80	2.279	0.027	Reject Ho (Significant)
	Experimental	30.83			

Reflection

Conducting research has been a journey of intellectual growth and self-discovery, one that has both challenged and enriched the researcher's understanding of the world and the process of inquiry itself. As the researcher reflects on their experiences in conducting research, several key insights come to mind.

First and foremost, the researcher has come to appreciate the power of curiosity. Research often begins with a question or a spark of interest, and it is this innate curiosity that propels the entire process forward. It is the drive to seek answers, to explore the unknown, and to uncover hidden truths that fuels the researcher's journey. The researcher has learned that nurturing and sustaining this curiosity is essential to the research endeavor.

Another profound lesson has been the importance of resilience and adaptability. Research is rarely a linear path from question to answer; it is more akin to navigating a labyrinth with unexpected twists and turns. The researcher has faced setbacks, encountered unforeseen challenges, and had to revise hypotheses and methods. Through these experiences, the researcher has developed resilience and the ability to embrace change. They have learned that setbacks are not failures but opportunities for growth and refinement.

Moreover, conducting research has deepened the researcher's appreciation for the complexity of the world and the multifaceted nature of knowledge. Research often reveals layers of intricacy and nuance that challenge preconceived notions. It has taught the researcher to approach each question with humility, recognizing that there is always more to learn and discover. It has also shown the importance of interdisciplinary thinking, as solutions to complex problems often require insights from multiple fields.

The research process has honed the researcher's critical thinking skills. It has taught them to evaluate information critically, to discern reliable sources from unreliable ones, and to approach evidence with a healthy skepticism. The researcher has come to understand that critical thinking is not just a tool for research but a valuable life skill that empowers them to make informed decisions and navigate an information-saturated world.

Furthermore, conducting research has underscored the significance of ethical conduct. It has emphasized the importance of treating research participants with respect, obtaining informed consent, and safeguarding their privacy. These ethical principles extend beyond the realm of research and inform the researcher's approach to ethical decision-making in various contexts.

Collaboration and teamwork have also emerged as essential aspects of the research journey. Working with colleagues, mentors, and peers has enriched the researcher's perspective and expanded their horizons. It has reinforced the notion that collective wisdom often leads to more profound insights and innovative solutions.

Lastly, the researcher has developed a deep appreciation for the iterative nature of research. Research is an ongoing process of revision, refinement, and reflection. It is a journey of continuous learning, where each discovery opens new avenues of inquiry. The researcher has learned to embrace this iterative process, recognizing that it is through iteration that knowledge evolves and advances.

Conducting research has proven to be a transformative experience, molding not only the researcher's academic pursuits but also influencing their approach to life. The process has instilled in the researcher a sense of wonder, resilience, and intellectual curiosity. It has underscored the significance of critical thinking, ethical conduct, and collaboration. The journey has revealed to the researcher that the pursuit of knowledge is a dynamic and ever-evolving process, one teeming with challenges and rewards. As the researcher persists on this path, they carry these invaluable lessons forward, eagerly anticipating the exploration of new questions and the contribution to the collective quest for understanding.

Summary of Findings

The study came out with the following salient findings:

1. The level of mastery of the learners in the pretest is "low mastery", and "moving towards mastery" level in the post-test for both the control and experimental group.
2. There is a significant difference in the level of mastery between the pre-test and post-test of learners in the control group and experimental group.
3. There is no significant difference on the level of mastery of the learners in the pre-test between the control and experimental group while there is a significant difference on the level of mastery of the learners in the post-test between the control and experimental group.

Conclusions and Recommendations

Conclusions

In the light of the findings, the following conclusions are presented.

1. The use of the loading scheme utilizing worked example strategy, and conventional instructional approaches like lectures, demonstrations, and textbook usage are both effective in teaching basic calculus in Grade 11.
2. The use of loading scheme utilizing worked example strategy, and conventional instructional approaches like lectures, demonstrations, and textbook usage in teaching basic calculus significantly increased the mastery level of the Grade 11 learners.
3. The conventional instructional approaches like lectures, demonstrations, and textbook usage in teaching basic calculus is more effective than using the loading scheme utilizing worked example strategy.

Recommendations

Based on the conclusions formulated in this study, the following recommendations are laid down.

1. Teachers are encouraged to embrace a blended instructional approach that involves incorporating the loading scheme strategy, which utilizes worked examples, along with conventional teaching methods such as lectures, demonstrations, and textbook usage. In implementing this approach, teachers should combine the interactive and step-by-step aspects of the loading scheme strategy with the depth and theoretical grounding offered by conventional lecture or textbook-based methods. This integration is designed to capitalize on the strengths inherent in each method, fostering a holistic and comprehensive learning experience for learners.
2. Teachers should engage in comprehensive training sessions and take advantage of professional development opportunities to effectively integrate loading scheme strategy, which utilizes worked examples, and conventional teaching methods such as lectures, demonstrations, and textbook usage into their lesson plans. Moreover, educators should play a pivotal role in the development and dissemination of teaching resources, including textbooks and supplementary materials. Additionally, teachers are urged to take the lead in implementing an assessment system that aligns with the integrated teaching methods, allowing them to gauge learners' proficiency and provide timely feedback for continuous improvement. Lastly, teachers should be proactive in encouraging ongoing research and evaluation to assess the sustained impact of the blended teaching methods on learners' mastery of basic calculus concepts.
3. Teachers should prioritize the continued utilization and refinement of conventional instructional methods, placing emphasis on lectures, demonstrations, and textbook-based approaches. School administrators should provide professional development opportunities and training sessions specifically tailored to enhance teachers' proficiency in employing these conventional methods. Additionally, educators should take the lead in developing and disseminating teaching resources, including textbooks and supplementary materials, that

align with and reinforce the effectiveness of conventional instructional approaches for teaching basic calculus. Lastly, teachers should be at the forefront of encouraging ongoing research and evaluation to explore nuances and variations within conventional teaching methods, ensuring a nuanced understanding of their effectiveness in the context of basic calculus education.

Action Plan

In response to the imperative to enhance the mastery of Grade 11 learners in basic calculus, this meticulously crafted action plan aligns with conclusive findings derived from recent research. The efficacy of a blended instructional approach, seamlessly integrating the loading scheme strategy and conventional teaching methods, is recognized in the pursuit of creating an enriched learning experience. The comprehensive action plan emphasizes the integration of effective instructional strategies while placing teachers at the forefront of this transformative initiative. Prioritizing professional development, resource development, collaborative environments, and ongoing research aims to create a dynamic and adaptive educational ecosystem. The goal is not only to disseminate knowledge but also to foster an environment where learners master basic calculus and develop critical thinking skills that will serve them beyond the confines of the classroom.

In the pursuit of a harmonious blend of instructional methods, the researcher will develop training modules aimed at equipping teachers with the skills to seamlessly integrate the loading scheme strategy into their lesson plans. Emphasis will be placed on combining the interactive and step-by-step nature of the loading scheme with the depth and theoretical foundation provided by traditional lecture or textbook-based methods. Workshops will be conducted both before the start of the academic year and throughout to ensure sustained implementation.

Recognizing the pivotal role of teachers in this endeavor, the researcher will organize comprehensive training sessions and professional development opportunities. These initiatives aim to empower educators to effectively integrate the loading scheme strategy and conventional methods into their teaching approaches. Continuous professional development sessions will be scheduled throughout the school year to allow teachers to refine their skills and adapt to evolving educational needs.

To support the blended instructional approach, the researcher will develop and disseminate teaching resources, including textbooks and supplementary materials. These resources will be meticulously aligned with the blended approach, catering to the specific needs and comprehension levels of Grade 11 students. The distribution of these resources will precede the academic year, ensuring preparedness among educators.

An integral component of the action plan involves the researcher implementing a robust assessment system aligned with both the loading scheme strategy and conventional teaching methods. This system aims to provide valuable insights into students' proficiency and guide continuous improvement efforts. The initiation of the new assessment system will coincide with the start of the academic year.

Recognizing the importance of collaboration, the researcher will actively encourage educators to participate in forums aimed at sharing successful practices and experiences related to the blended instructional approach. Regular collaborative initiatives will be established to facilitate ongoing dialogue among educators throughout the academic year.

The commitment to improvement includes promoting ongoing research and evaluation. The researcher will establish a research committee to explore nuances and variations within both the loading scheme strategy and conventional teaching methods. Teachers will be encouraged to actively participate in research initiatives throughout the academic year.

To ensure the broader educational community benefits from the research, the researcher will disseminate findings through conferences, workshops, and publications. Summaries of the research will be created, making the information easily accessible to educators, administrators, and policymakers. Dissemination activities will be initiated within six months of the study's completion.

Through the implementation of this action plan, the researcher aims to create a dynamic and engaging learning environment that maximizes the benefits of both instructional strategies, ultimately enhancing the mastery of basic calculus among Grade 11 learners.

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Financial Report

A. Supplies and Materials							
Activity	Item	Unit	Qty	Estimated Cost	Total	Actual Cost	Total
Implementation of the study and Preparation of Research Papers, Instructional Materials/ Worksheets, and other documents	A4 Bond Paper	Rm	10	250.00	2,500.00	230.00	2,300.00
	A4 Folder Tag board with fastener	Pc	20	10.00	200.00	10.00	200.00
	Printer Ink Black	Bottle	10	300.00	3,000.00	290.00	2,900.00
	Printer Ink Cyan	Bottle	3	300.00	900.00	300.00	900.00
	Printer Ink Magenta	Bottle	3	300.00	900.00	300.00	900.00
	Printer Ink Yellow	Bottle	3	300.00	900.00	300.00	900.00
	USB Flash Drive	Pc	1	1,000.00	1,000.00	1,000.00	1,000.00
	Expanding Envelope	Pc	48	20.00	960.00	20.00	960.00
	Ballpen	Pc	96	15.00	1,440.00	12.00	1,152.00
	Pencil	Pc	96	15.00	1,440.00	12.00	1,152.00
B. Domestic Travel Expenses							
Submission of First Tranche Deliverables with wet Signature	Courier		1	300.00	300.00	300.00	300.00
C. Food and other incurred expenses during the conduct of research							
Validation of Pre-Test, Posttest and Worksheet Materials	Meals and Snacks of Evaluation Team	Pax	5	500.00	2,500.00	500.00	2,500.00
Implementation of the Intervention	Snack of Learners/Participants (Control and Experimental Group)	Pax	48	100.00	4,800.00	120.00	5760.00
D. Reproduction, Printing, and Binding Cost							
E. Communication Expenses for the Implementation / Conduct of the Study							
Implementation of the study - Data Gathering /Collection, Preparation and submission of research papers and other documents	Cellphone and Internet Load	Card	6	1,000.00	6,000.00	1,000.00	6,000.00
F. Other Expenses							
					26,840.00		**26,924.00**

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