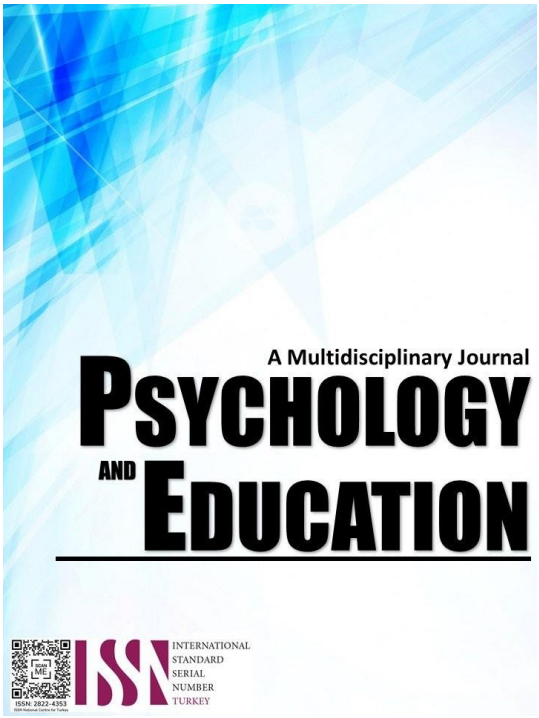
EFFECT OF FLEXIBLE LEARNING MODALITIES ON THE MATHEMATICAL SKILLS OF GRADE 10 STUDENTS



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Research Article

Effect of Flexible Learning Modalities on the Mathematical Skills of Grade 10 Students

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Abstract

The flexible learning modality empowers both learners and teachers to adjust to a variety of learning styles, preferences, and circumstances. This approach acknowledges the diverse needs of students, offering a range of alternatives beyond the traditional, one-size-fits-all educational model. In this study, a flexible learning material was designed as a strategic innovation to enhance the mathematical skills of Grade 10 students at Esperanza National High School for the school year 2022-2023. The primary tool used was adapted from the Grade 10 Mathematics Self-Learning Modules provided by the Department of Education, focusing on the Quarter 1 lessons. These materials were designed to target key skills, including comprehension, computation, vocabulary, and the recognition of mathematical symbols. The research employed a quantitative methodology, specifically a quasi-experimental design. The findings revealed that students in the experimental group, who were exposed to the blended learning modality using the flexible learning materials created by the researcher, showed significant growth in their problem-solving abilities and overall mathematical competence. In contrast, students in the control group, who continued with conventional learning methods, demonstrated little to no improvement. The results highlight that learner engaged in the blended learning modality outperformed their peers, scoring considerably higher than those taught through traditional methods. Overall, the flexible learning modality proved to have a highly positive impact on students' mathematical skills, promoting adaptability and resilience in problem-solving.

Keywords: *flexible learning modality, mathematical skills, conventional learning modality, blended learning modality*

Introduction

The COVID-19 pandemic has had a profound impact on the mathematics performance of Filipino students, as reflected in both local and international assessments such as the National Achievement Test (NAT), Programme for International Student Assessment (PISA), and Trends in International Mathematics and Science Study (TIMSS). For Grade 10 students, the NAT results reveal that Filipino subjects achieved the highest mean percentage score (MPS) at 57.2%, English at 51.8%, mathematics at 47.8%, and science at 44.5%.

In global assessments, Philippine students significantly underperformed compared to other nations. In the 2018 PISA, the Philippines ranked the lowest among 79 participating countries, and in the 2019 TIMSS, it ranked last out of 58 nations, with 15-year-olds and Grade 4 students being evaluated, respectively (Tadalan, 2021). Former Secretary of Education, Leonor Briones, emphasized that PISA is a tool to gauge the effectiveness of the country's reform strategies aimed at globalizing education. As the Philippines joined PISA in 2019, the Department of Education (DepEd) responded by conducting online courses to enhance teacher skills and address the challenges of delivering quality education during the pandemic (DepEd, 2019).

Mathematics education presents specific challenges, such as decreasing learner motivation and performance. To address these, educators must become more innovative, integrating new methods and technologies into teaching. Flexible learning, particularly gamification, has emerged as a solution that reduces stress and enhances student motivation. According to Dichev et al. (2017), gamified learning environments make education more dynamic, engaging, and exciting, fostering positive attitudes and a desire to learn.

The pandemic triggered a shift from traditional, face-to-face teaching methods to online learning, demanding that schools adapt to a more digital educational landscape (Crawford et al., 2020; Syauqi et al., 2020). The Commission on Higher Education (CHED) also promoted using distance learning methods, including instructional technologies, to extend academic terms during the pandemic (Hallare, 2020). Web-based learning, as defined by Ariyanti and Santoso (2021), allows students to participate in classes remotely via the internet, offering flexibility and accessibility (Florence & Anthony, 2019; Ferreira et al., 2018).

Despite its advantages, web-based learning has proven particularly challenging in the Philippines, especially for mathematics courses (Cortez, 2020). Tyaningsih et al. (2020) highlighted the flexibility of online learning but noted difficulties such as limited instructional materials and inconsistent student engagement. Ariyanti and Santoso (2021) also found that students' enthusiasm for mathematics decreased after transitioning to online learning, as many faced challenges in accessing adequate learning materials for assigned tasks.

Guansi et al. (2020) reported that Filipino students prefer a learning system where educators explain lessons and then assess their understanding, underscoring the need for educational institutions to better equip teachers with the skills, materials, and interactive learning media necessary for effective online instruction (Syauqi et al., 2020).

To address these gaps, research suggests using instructional videos to enhance mathematics learning. Students tend to respond

positively to video-based instruction, which can increase engagement and encourage innovative teaching methods (Ariyanti & Santoso, 2021; Tanujaya et al., 2021). Similarly, Wang's study on online undergraduate math courses revealed that students performed better on assessments when they used fewer tools, demonstrating the effectiveness of focused, video-supported learning (Pal & Patra, 2020).

Given these insights, the use of teacher-produced instructional videos is recommended as a strategy to adapt and improve mathematics education, particularly for Grade 10 students at Esperanza National High School, in response to the pandemic's challenges. These videos can provide more accessible, engaging, and effective learning experiences, helping to bolster students' mathematical abilities in a flexible and adaptable manner.

Research Questions

The study evaluated the mathematical skills of Grade 10 learners in flexible learning modalities of Esperanza National High School in Poblacion, Esperanza, Sultan Kudarat. It answered the following questions:

1.What is the level of the mathematical skills of the experimental and control groups in the pretest in terms of:
  1.1 comprehension;
  1.2 computation;
  1.3 vocabulary; and
  1.4 recognition of symbols?
2. What is the level of the mathematical skills of the experimental and control groups in the posttest in terms of:
  2.1 comprehension;
  2.2 computation;
  2.3 vocabulary; and
  2.4 recognition of symbols?
3. What are the mean gain scores of the experimental and control groups in:
  3.1 comprehension;
  3.2 computation;
  3.3 vocabulary; and
  3.4 recognition of symbols?
4. Is there a significant difference between the mathematical skills of the experimental and control groups in the pretest in terms of:
  4.1 comprehension;
  4.2 computation;
  4.3 vocabulary; and
  4.4 recognition of symbols?
5. Is there a significant difference between the mean gain score both under control and experimental groups in terms of:
  5.1 comprehension;
  5.2 computation;
  5.3 vocabulary; and
  5.4 recognition of symbols?

Literature Review

Flexible Learning Method

Flexible learning is a general one that can have many distinct meanings. In a broader sense, flexible learning arrangements accommodate the various needs of students and encourage them to assume more personal responsibility for their education. Learners and their needs are at the center of flexible learning, and the educational services provided should give them the freedom to choose what, when, how, and where they learn (Wanner & Palmer, 2015).

Most flexible learning initiatives center on temporal and spatial aspects of learning, which are now primarily realized through new technologies and didactically implemented in an online or blended learning environment (Andrade & Alden-Rivers, 2019).

Barriers that can keep students from participating in a particular educational context are removed with flexible learning environments. Flexible delivery is considered an important component of technology development going forward as it typically enables learners and instructors to communicate in a two-way fashion. Later, flexible learning was expanded to include flexible pedagogy and delivery (Gordon, 2014; Ryan & Tilbury, 2013). According to Gardon (2014) and Ryan and Tilbury (2013), flexibility is the quality of educational practices institutions and students use.

Additionally, the researchers discovered that the effectiveness of online learning approaches appears 30 quite broad. In other words, undergraduate and graduate programs and academic and professional students have found online learning effective. According to several academics, the body of research comparing online and offline courses has mostly been completed (Bernard et al., 2004; Clark, 2000; Gunawardena & McIssac, 2004; Lockee et al., 2001; Mishra & Koehler, 2006; Yen et al., 2018).

Conventional Learning Method

The instructional method of the classroom has a long history, and teaching methods and structures have been perfected over many years. The advantages of face-to-face training over online instruction are considerable (Xu & Jaggars, 2016).

Education in the classroom is quite dynamic. Traditional classroom learning offers face-to-face instruction in real time and generates creative inquiries. Additionally, it enables quicker instructor responses and more adaptable curriculum delivery. Because students must confine their inquiries to blurbs and give the teacher and other students time to answer, online instruction slows down the learning process. However, as technology advances, online instruction will likely become more effective, improving classroom interactions and bringing students and teachers closer together. However, for the time being, face-to-face instruction offers dynamic learning qualities that online instruction does not (Kemp & Grieve, 2014).

Traditional classroom instruction is a tried-and-true method. Some students are resistant to change and have negative opinions of online education. These students might be technophobes who feel more at ease taking notes in a classroom than using a computer to learn new information. Other students might emphasize face-to-face communication, pre- and post-class conversations, group learning, and organic relationships between students and teachers. They could believe that the internet makes learning more difficult. Some students may only attend class activities if they like the teaching style; as a result, their grades may improve, and they may lose interest in learning. However, students may get used to online learning. Students can be required to only take Web-based courses as more universities use computer-based training. While true, this still needs to change the fact that some students prefer a more intimate learning environment (Paul & Jefferson, 2019).

Blended Learning Method

The study of López-Pérez et al. (2011), as cited by Graham et al., 2013 shows that blended learning positively affects dropout rates and a positive attitude toward improving exam marks. Additionally, the students' evaluations of their attitude toward and readiness for blended learning are linked, and their final grades depend on the activities used in blended learning and the student's age, background, and class attendance level.

Online and in-person training are the two key components in defining blended learning. Additionally, blended learning combines in-person and online instruction, including some of the features of online courses. According to (Tayebinik & Puteh, 2013), blended learning systems combine in-person training with computer-mediated instruction.

The advantages of traditional classroom instruction and ICT-supported learning, including offline and online learning, are combined in blended learning. Cooperative learning, constructive learning, and computer-assisted learning (CAI) are all possibilities. For blended learning to be successfully implemented, there must be diligent efforts, the proper attitude, a sizable budget, and highly motivated teachers and students. It is complex and difficult to organize because it combines several modes (Dangwal, 2017).

Mathematical Skills

Numeracy and mathematical skills are essential to succeeding in everyday life and pursuing higher education and careers. Despite its importance, numeracy skills remain an ongoing challenge for several students, particularly those struggling with mathematics (Dizon & Lumapenet, 2023).

It is crucial to note that the existing body of research has typically used curriculum or standardized measurements of math achievement, which cover a range of mathematical skills. Any meaningful connection between numerical magnitude representations and mathematics will be different for people with varying levels of mathematical proficiency. In other words, some areas of mathematical proficiency will place more weight on numerical magnitude processing than others. In order to investigate these particular relationships, more precise measurements of mathematical performance will be required (Vanbinst & De Smedt, 2016).

Mathematical tasks need one of the following abilities: fundamental number sense, whole-number computation, word problem-solving, fractions, geometry, and algebra. Tasks that draw on one or more of the following mathematical skills were specifically coded as basic number knowledge: counting words, Arabic digits, ordinality, numerosity, and knowledge of approximate number system (Verdine et al., 2014).

Mathematics is an important science to be learned because mathematics is a science that has unique characteristics as science, which has an abstract object, a pattern of axiomatic and deductive thinking, and is based on truth. With such unique characteristics, mathematics is useful in developing skills and creating a learner's personality (Trisnawati et al., 2018).

Mathematics as a foundational science is also necessary to succeed at a high level. As a result, math is taught at all levels of education, from kindergarten to university. In addition, mathematics is a science used in everyday life to solve problems.

One of mathematics' roles is to prepare learners in order to be able to face the changing conditions or challenges in life, which always develop. Besides, the learner is expected to be able to apply mathematics and think mathematical in daily life (Yusrina, 2017).

Because of this, mastering mathematics requires more than just a theoretical understanding of how to solve problems. As cited by Imswatama and Lukman 2018), the way of solving a problem that the learner obtains is a result of knowledge and experience that the

learner has related to the problem that he wants to solve. To expand the student's understanding of mathematics, the instructor must be able to support students in giving their math lessons significance and in developing their ability to solve mathematical problems.

According to Indonesian Minister of Education Indonesia Regulation No. 23, 2006, all students at all educational levels must receive mathematics lessons to develop the learner's logical, analytical, systematic, critical, creative, and cooperative thinking capacities. Accordingly, thinking critically is one of the skills a learner must possess after studying mathematics.

The association between students' mathematical skills and socioeconomic, demographic, and ontogenetic characteristics is the subject of numerous scientific investigations. It answers queries about how students' mathematical abilities are developed concerning their strengths and shortcomings and concerns about the practical application of mathematics (Stańdo et al., 2023).

During the COVID-19 pandemic's final two years, many students needed to be addressed in math classes, creating a large learning gap. As a result, when students returned to face-to-face classes, I saw them needing help to answer and understand basic math concepts. Studies show that the COVID-19 pandemic has adversely affected Mathematics education, with many students suffering from learning disabilities and lagging in Mathematics skills (Dizon & Lumapenet, 2023)

While instruction learners are among boredom and aggravation, frustrated learners cannot master quantitative dimension mathematical skills. Frustrated students make up 0–74%, instructional students make up 75–90%, and independent students make up 91–100%, according to an analysis of solving arithmetic problems. The speed and accuracy of reading (stories/problems) are also discussed linearly. Due to incorrect word meanings, frustrated learners struggle to assimilate information. Additionally, compared to instructional and autonomous learners, information reading errors are more common (Harsela et al., 2021).

Comprehension

To study mathematics, students must possess the critical skill of mathematical comprehension. However, because flexible learning is a new approach and is not frequently utilized in everyday settings, it is difficult to gain mathematical comprehension even as pandemics continue to spread and many universities have adopted it.

The ability to learn in the new normal also depends on metacognition. When faced with new kinds of online learning, student's knowledge of their internal evaluation of how they learn and their ability to determine which methods are beneficial needs to be developed because they need more cognitive flexibility (Tusoy & Tan, 2022).

According to Akbasli et al. (2016), students should focus on mathematics and science to improve their reading comprehension and overcome academic achievement obstacles. Students may require assistance from their families and teachers in this situation. Therefore, parents, families, and teachers should encourage their children to read because reading comprehension and self-esteem are important components of academic achievement for children. Teachers should stress the significance of reading comprehension in their lessons and plan the lectures and activities in the classroom accordingly.

Teachers should teach their students to think mathematically because it is a way of thinking. Math places a strong emphasis on considering the connections between facts. Its method of thought is the same as that used to analyze the relationships and experiences related to the social and economic issues that adults confront daily. It consistently demonstrates thought processes in plain form and disapproves of haphazard approaches. As a result, learning mathematics helps you make sense of everything and makes life easier. These regular tasks, as well as many others, involve mathematical and logical thinking. Therefore, solid mathematics comprehension is necessary to make sense of all the numbers and resolve life's challenging difficulties (Anjum, 2015).

Computation

In the learning process in class, the teacher has to instill problem-solving skills and think critically about mathematics by relating mathematics problems with daily life and cultural values in society (Owusu-Darko et al., 2022). Both are necessary for a learner to understand cultural values in society and mathematics. Problem-solving abilities and mathematical critical thinking still need to catch up in Indonesian students. For the 2016 PISA survey on mathematics, Indonesian students performed in the top 63 out of 69 nations, as seen by their placement.

The development of computational skills in the group using digital manipulatives is consistent with NAEYC's stance that children benefit and learn meaningfully when digital technology is purposely and consciously used. According to the findings, digital manipulatives are not just "edutainment," as some detractors contend, but another possible instrument for enhancing computing skills (Mattoon et al., 2015).

Critical thinking skill is needed to solve a problem that is faced in daily life (Imswatama & Lukman, 2018). As a result, the learning process should pay particular attention to developing critical thinking skills, especially when performing math.

Additionally, based on observations made in some schools in the Sukabumi Municipality, the teacher still uses traditional teaching methods in the classroom. These methods often start with an instructive explanation of the subject, followed by an example test, and end with an exercise test. As a result, learning mathematics is more focused on memorization of procedures than on problem-solving or critical thought.

Few junior high school mathematics textbooks provide activities based on problem-solving or critical thinking. As a result, junior high school teachers need teaching materials that will aid in developing students' problem-solving abilities and capacity for critical thought. Teaching aids should make it easier for teachers to impart information and value. In order to impart local wisdom value in the learner's context in addition to mathematical knowledge. According to Fitroh and Himawati (2015), as cited by Imswatama and Lukman (2018), education and culture cannot be avoided daily because culture is a unity applied in society.

Vocabulary

Mathematical Vocabulary and language have gained interest in mathematics education because they can be confusing (Powell et al., 2021). The assessment of mathematics vocabulary in the elementary and middle school grades. Diversity dimensions in mathematics and language learning, 313-330. Students must be able to speak and write about mathematics and hear and read it, according to Livers and Bay-Williams' (2014) explanation.

According to Lin (2022), mathematics vocabulary is one part of the academic language but not the sole. One needs a mathematical vocabulary to understand and communicate about mathematics. The terminology used in mathematics can be divided into four groups: technical, subtechnical, general, and symbolic. Technical terminology, such as reciprocal and numerator, have a single, mathematically-specific meaning. Mathematics-specific subtechnical terminology, such as "round" and "regroup," have multiple meanings. The phrases students encounter in mathematics from common English include more and longest. Symbolic vocabulary words explain numbers and symbols to describe performance differences associated with mathematics vocabulary (Powell et al., 2017)

Recognition of Symbols

One of the courses that can be studied in conjunction with others is mathematics. It includes physics, science, civil engineering, and others. As a result, arithmetic is studied and taught to students at both college and civil colleges. Students need to comprehend the mathematical symbol and the problem to solve math problems. Recognition of mathematical symbols refers to the capacity to comprehend a mathematical symbol's meaning and be aware of it.

When solving problems, the mathematical symbol is crucial for conveying the concept to others. The symbols themselves provide the foundation for communicating a concept. Their understanding of the mathematical symbols demonstrates the student's comprehension of the mathematical problem. Not comprehending a mathematical symbol can impede concept creation, comprehension, and communication. By simulating the circumstance for real-world use, symbol as a cognitive function aids a person in resolving the subjectively challenging situation (Zukhrufurrohmah & Putri, 2020).

According to Kukreja and Sakshi (2022), machine recognition of handwritten mathematical text and symbols has grown significantly in practical significance and application due to the prevalence of handwriting and mathematical content in human transactions. Mathematical symbol recognition (MSR) is a necessary phase in the overall recognition process, and mathematical expression recognition (ME) has remained a difficult and developing study area. Even for optical character recognition, the recognition jobs are challenging due to the large diversity of symbols and recurrent characters and the numerous variances in writing styles.

Mathematical symbols can be divided into three groups: letters (including letter-like shapes from any language), other figures, and compound templates, which combine letters and figures into a two-dimensional shape. Combining the ideas mentioned earlier can result in symbolic statements that might be long or short (Bardini, Caroline & Pierce, Robyn. (2015).

Methodology

This section relates to research design, study locale, population and sampling design, ethical consideration, data-gathering procedure, and statistical tools.

Research Design

A quasi-experimental pretest, posttest, and control group design was used in this study. An identical comparison group to the treatment group concerning baseline characteristics is determined by quasi-experimental designs (White & Sabarwal, 2014). The respondents were two (2) sections of Grade 10 students of Esperanza National High School with equal competencies, and they were assigned either into a control group or an experimental group through drawing lots. The pretest was administered to both groups before the experiment.

During the conduct of experimentation, the Conventional method of teaching was employed by the control group. In contrast, the experimental group was exposed to blended learning, which combines conventional and flexible learning modalities. The researcher prepared fourteen (14) video lessons, which were utilized for experimentation. After the intervention, the same test, which served as a posttest, was given to both groups.

Participants

The study respondents were Grade 10 Junior High School learners enrolled in Esperanza National High School in the academic year 2022-2023. The NAT was administered annually, so they were selected as study respondents. According to Grade 10 students' NAT results from 2009 to 2015, the mathematics subject trails with 47.8%, lowered to 37.30% in 2016-2017 and 34.26% in 2017-2018.

Two (2) heterogeneous sections from the said institution were randomly selected, completing the necessary data for this study. The sections set were Einstein, designated as the experimental group, and Faraday section as the control group. These two sections were both heterogeneous. To guarantee that there could be no contamination due to the spread of information that students are involved in during the entire process, the researcher collaborated with the subject teachers and advisers of the two groups.

Table 1. *Table of Distribution of Respondents*

Total Population of the Class		
Male	*Female*	*Total*
14	37	51
13	38	51

Out of 51 experimental group students, 14 (27%) were male and 37 (73%) were female, and out of 51 control group students, 13 (25%) were male and 38 (75%) were female. The age range was between 14-16 years in both groups. The socio-economic and cultural conditions of the respondents were the same.

Instruments

The researcher utilized 1 set of questionnaires to gather the needed data and information. Eighty-five test questions were utilized during pilot testing, and the reliability of the test questionnaire was analyzed using Cronbach alpha. The remaining test items were used as pretest and posttest material to test students' mathematical skills.

The test questionnaire was adapted from the Grade 10 Self-Learning Modules distributed by the DepEd. Before pilot testing, the test items were tested for face and content validity by math teachers, the head of the mathematics department, and the education program supervisor for mathematics of the Division of Sultan Kudarat. It was done to ensure the instrument would measure what it intended.

The final instrument included an 80-item test with a Cronbach Alpha reliability of 0.869 for comprehension, 0.813 for computation, 0.758 for vocabulary, and 0.901 for symbol recognition, which showed reliability within the acceptable ranges. Cronbach alpha is one of the most significant and widely used statistics in research (Taber, (2018). Before and following the intervention, the responders took the test.

The raw results are converted to achievement scores:

Table 2. *Mean Percentile Score*

MPS	*Descriptive Equivalent*
96 – 100%	Mastered
86 – 95%	Closely Approximating Mastery
66 – 85%	Moving Towards Mastery
35 – 65%	Average
15 – 34%	Low
5 – 14%	Very Low
0 – 4%	Absolutely No Mastery

Before and after the intervention, the achievement levels of the experimental and control groups were assessed using the mean percentage score (MPS). It was adapted from the DepEd Memorandum No. 160, series of 2012.

The t-test was used to compare the accomplishment levels of the experimental and control groups before and after the intervention. The study's main data source was analyzing the students' pretest and posttest results. The two groups' pretest and posttest scores were compared using the t-test, a statistical technique for determining whether there was a statistically significant difference between the mean scores of the two groups before and after the intervention.

Hence, the t-test on a dependent sample was used to evaluate whether there was a statistically significant difference between each group's pretest and post-test results. The independent sample's t-test was also utilized to determine whether there was a significant difference between the experimental and control groups' post-test mean scores.

Procedure

Upon receiving approval for the study's outline, the researcher sought permission from the Dean of the Graduate School to proceed. Following this, formal written consent was requested from the administration of Esperanza National High School to conduct the research and gather relevant student data.

The researcher coordinated closely with the advisers at Esperanza National High School to facilitate the administration of the tests. Once the required data was secured, the researcher commenced the data collection process using a validated instrument.

A pretest, consisting of 80 items, was administered to the experimental and control groups. The experimental group was exposed to the blended learning modality, which has been shown to positively impact reducing dropout rates and fostering a more positive attitude toward academic performance. Research suggests that students' readiness and attitude toward blended learning are interconnected, and

their final academic outcomes are influenced by various factors such as the activities employed in blended learning, as well as their age, background, and attendance (Graham et al., 2013). In contrast, the control group followed the traditional face-to-face learning approach. This conventional instructional method, honed over years of practice, has proven advantages, especially in offering direct interaction and feedback (Xu & Jaggars, 2016).

Results and Discussion

This section contains the findings from the analysis and interpretation of the information gleaned from the responses to the questionnaires given to the study's subjects. According to the sequence of the issue statements, the data were presented in tabular form.

Table 3. *Level of Mathematical Skills of the Experimental Group in the Pretest*

Mathematical Skills	*Mean*	*Percent*	*Description*
Comprehension	8.00	40.00%	Average
Computation	7.35	36.75%	Average
Vocabulary	8.45	42.25%	Average
Recognition of Symbols	5.25	26.25%	Low
Section Mean	7.26	36.30%	Average

The mathematical skills of learners in the experimental group are generally average. It is represented by the section mean of 7.26, which means that, on average, students in the experimental group got 36.30% of the correct answers in the pretest.

The results describe the mathematical skills of the experimental group as "average" in comprehension, computation, and vocabulary. It specifies that the learners have prior knowledge of the mathematical skills being tested.

Among the three mathematical skills described as average, learners got the highest mean in vocabulary, which is 8.45 (42.25%). It indicates that learners who belong to the experimental group have a better understanding of mathematics vocabulary. However, the students in the experimental group described low recognition of symbols. Hence, they need to improve their skills in recognizing symbols. It implies they failed to recall or remember some mathematical symbols.

Learning new vocabulary is a fundamental part of understanding math concepts. It does not seem like the most logical place for word walls, glossary lists, and word-of-the-day activities would be in math class. However, comprehending concepts requires a solid grasp of math terminology; thus, tactics for developing a strong vocabulary are surprisingly helpful (Noonoo, 2022).

Palmieri (2022) states that regular practice with new terms facilitates mathematical communication and understanding. It is more of learning architecture in which ideas must be investigated, and a road to knowledge must be carved out before a mathematical term can be used to identify its meaning.

Table 4. *Level of Mathematical Skills of the Control Group in the Pretest*

Mathematical Skills	*Mean*	*Percent*	*Description*
Comprehension	8.25	41.25%	Average
Computation	7.43	37.15%	Average
Vocabulary	7.82	39.10%	Average
Recognition of Symbols	5.00	25.00%	Low
Section Mean	7.12	35.60%	Average

The overall rating of students' mathematical skills in the control group is average. It has a section mean of 7.12, which implies that students in the control group got 35.60% of the precise answers in the pretest.

The control group's mean comprehension, computation, and vocabulary scores are 8.25, 7.43, and 7.82, respectively. The control group scored the highest mean in comprehension out of the three mathematical skills that were considered average. It indicates that they have a solid understanding of mathematical concepts. However, they were described as low in recognition of symbols. It implies that the students failed to recognize some mathematical symbols in Patterns and Algebra. A crucial component of the mathematics curriculum is comprehension. Strong language abilities are essential for students to employ logic and reasoning while answering math questions. Training children to understand the significance of symbols, numbers, and more is as important as teaching them to memorize facts or work through algorithms. At the same time, these skills are beneficial (Oxford Primary, 2018).

The ability to learn in the new normal also depends on metacognition. When faced with new kinds of online learning, students' knowledge of their internal evaluation of how they know and their ability to determine which methods are beneficial needs to be developed because they need more cognitive flexibility (Tusoy & Tan, 2022).

Table 5. *Level of Mathematical Skills of the Experimental Group in the Posttest*

Mathematical Skills	*Mean*	*Percent*	*Description*

Comprehension	11.20	56.00%	Average
Computation	10.78	54.00%	Average
Vocabulary	13.00	65.00%	Average
Recognition of Symbols	9.12	46.00%	Average
Section Mean	11.03	55.13%	Average

The students in the experimental group generally demonstrated average mathematical skills, as figured out by a mean of 11.03. It indicates that learners assigned to the experimental group correctly answered 55.13% of the questions in the posttest.

Based on the data set, the experimental group received mean scores of 11.20, 10.78, 13, and 9.12 in comprehension, computation, vocabulary, and recognition of symbols, respectively. The experimental group performed best in vocabulary, with a mean score of 13 (65%) out of all the mathematical skills assessed. It shows that students in the experimental group are prepared and educated regarding mathematical vocabulary.

Math education must have a strong math vocabulary component. Understanding math terminology is crucial for comprehending ideas, expressing thoughts, boosting confidence, preparing for exams, and developing critical thinking abilities. We can assist learners in developing a solid foundation in mathematics and position them for success in their future academic and professional activities by prioritizing math vocabulary instruction (Location West Chester, 2023).

According to Morgan (1996), Moschkovich (2015), and Simpson and Cole (2015), mathematics vocabulary is one part of the academic language but not the sole one.

Table 6. *Level of Mathematical Skills of the Control Group in Posttest*

Mathematical Skills	*Mean*	*Percent*	*Description*
Comprehension	7.82	39.10%	Average
Computation	6.51	32.55%	Low
Vocabulary	8.94	44.70%	Average
Recognition of Symbols	5.43	27.15%	Low
Section Mean	7.18	35.88%	Average

The section mean of 7.18 signifies that the students in the control group had average mathematical skills in their posttest. It shows that students in the control group correctly answered 35.88% of the posttest questions.

The posttest results showed that the control group's mathematical skills are average regarding comprehension and vocabulary only, with mean scores of 7.82 and 8.94, respectively. These denote that learners under the control group have improved their mathematical skills in comprehension and vocabulary during the posttest. On the other hand, the learners got low in computation and recognition of symbols, with mean scores of 6.51 and 5.43. It implies that learners in the control group struggle with problems involving computation and recognition of symbols.

The outcome is consistent with the research by Tomkins, Ramesh, and Getoor (2016), where they found that only 70% of the students who had an overall score of 90 or higher completed the posttest. Similarly, just 63% of students who finish 90% of the course succeed in the posttest. The preliminary findings indicate the need for a more thorough investigation to comprehend the various student populations enrolled in the course.

The students' evaluations of their attitude toward and readiness for blended learning are linked, and their final grades depend on the activities used in blended learning and the student's age, background, and class attendance level (Graham et al., 2013).

Table 7. *Mean Gain Scores of the Experimental Group*

Mathematical Skills	*Pretest mean*	*Posttest mean*	*Mean gain*
Comprehension	8.00	11.20	3.20
Computation	7.35	10.78	3.43
Vocabulary	8.45	12.67	4.22
Recognition of Symbols	5.25	9.12	3.86
Section Mean	7.26	10.94	3.68

The mean gain scores of the experimental group are 3.20, 3.43, 4.55, and 3.87 in comprehension, computation, vocabulary, and recognition of symbols, respectively. The positive mean gain implies that learners exposed to blended learning modality have improved their mathematical skills. It is also noticeable that the students made progress in learning Math 10.

Table 7 shows a mathematical difference between the experimental group's pretest and posttest scores based on the pretest and their mean gain. The flexible learning modality material in mathematics is likely effective in improving the students' mathematical skills.

The results of this study are parallel to the survey conducted by Lantajo and Tipolo (2019), which revealed that students with blended learning modality gain better performance in mathematics. The experimental group's significant improvement between the pre and

posttests shows that the blended learning approach successfully improves students' mathematical proficiency.

On the contrary, Paculanan (2013) asserted that direct instruction is a valuable teaching strategy that can enhance students' performance in mathematics and should not be disregarded while teaching the subject.

Table 8. *Mean Gain Scores of the Control Group*

Mathematical Skills	*Pretest mean*	*Posttest mean*	*Mean gain*
Comprehension	8.25	7.82	-0.43
Computation	7.43	6.51	-0.92
Vocabulary	7.82	8.94	1.12
Recognition of Symbols	5.00	5.43	0.43
Section Mean	7.13	7.18	0.05

The control group obtained mean gain scores of -0.43, -0.92, 1.12, and 0.43 in comprehension, computation, vocabulary, and recognition of symbols, respectively. The results imply that some students got low scores during the posttest, which resulted in negative mean gains in comprehension and computation. It indicates that students have no progress after they were subjected to conventional learning modality. In a traditional learning modality, students only participate in class activities if they find the instructor engaging. It could lead to a decline in their academic performance and a lack of enthusiasm for learning. It could result in low scores on their exams. However, students may get used to online learning. Students can be required to only take Web-based courses as more universities use computer-based training. While true, this still needs to change the fact that some students prefer a more intimate learning environment (Paul & Jefferson, 2019).

The finding reveals a significant difference between the pretest and posttest results for the control group. It shows that several students struggled with math and had a weak conceptual understanding of Math 10. It means that the conventional teaching method alone is insufficient for the students to learn the concepts in Math 10.

The findings aligned with the study by Zakaria et al. (2010), as cited by Setti (2020), who claim that traditional teaching techniques are teacher-centered, giving students fewer opportunities for collaboration, problem-solving, and discussion.

As cited by Bishara (2018), the instructor imparts knowledge to all students in the same way, regardless of their differences. Those who establish the standards set the curricular structure and impose it on the students. The scant use of illustrative methods in instruction presents a barrier to less proficient students, making it more difficult for them to comprehend the topic despite their best efforts.

Table 9. *Analysis of Comprehension Skills in the Pretest of the Experimental and Control Groups*

Group	*N*	*SD*	*Mean*	*t-comp*	*P-value*
Experimental	51	2.43	8.00	0.48	0.63
Control	51	2.92	8.25		

α=0.05 level of significance

The table reveals the computed mean of experimental and control groups. The experimental group got a mean of 8.0 with a standard deviation of 2.43. At the same time, the control group got a mean of 8.25 with a standard deviation of 2.92. Given that the t-computed of 0.48 is less than the p-value of 0.63 at the 0.05 significance level, it may be inferred that the two groups' levels of mathematical comprehension were nearly identical. The outcome supports the hypothesis that the difference in mean score between the experimental and control groups is due to chance. The control and experimental groups' standard deviations revealed that the scores were reasonably close.

It connotes that students in both groups were not exposed to the content covered on the pretest before the exam was administered. It only means that the two groups are comparable regarding their comprehension skills.

The findings in Table 9 are supported by the study of Imbat (2012), as cited by Azizifar et al. (2015), who pointed out that the results of the two groups in the pretest were almost similar level of academic preparedness before the conduct of the study. In addition, Taclay (2013) mentioned that before the study, the students' performances in both control and experimental groups were moderately low and comparable.

In the study of Jullar and Magbanua (2016), which included 73 participants, the t-test was utilized to ascertain whether there was a significant difference between the means of the two (2) groups.

The suitable test to compare differences between small samples, usually consisting of 30 or fewer, is the t-test. Nonetheless, larger sample sizes are frequently employed when using the t-test for Independent Samples (MacFarland et al., 2021).

Table 10. *Analysis of Computation Skills in the Pretest Scores of the Experimental and Control Groups*

Group	*N*	*SD*	*Mean*	*t-comp*	*P-value*
Experimental	51	2.64	7.35	0.14	0.89

Control	51	2.97	7.43		

∝=0.05 level of significance

The experimental group had a mean of 7.35 in computational skills. The control group obtained 7.43 during the pretest. The comparison of the computation skills of the two groups resulted in t-computed = 0.14 with a probability of 0.89, which is higher than ∝=0.05. It suggests sufficient evidence to claim that the mathematical difference between the mean scores of the experimental and control groups in the pretest is due to chance.

The results imply that at the start of the experiment, the experimental group may have the same computational skills as the control group. The study of Balala (2016) stresses that student respondents in both experimental and control groups should have the same knowledge before introducing the lesson and implementing experimentation.

In the learning process in class, the teacher has to instill problem-solving skills and think critically about mathematics by relating mathematics problems with daily life and cultural values in society (Alangui, 2017; Cimen, 2014; Eyal, 2018). Both are necessary for a learner to understand cultural values in society and mathematics.

The type of outcome determines the statistical techniques applied in the data analysis. If the outcome data consists of continuous variables, the researchers might be interested in determining whether the mean values of the two groups differ significantly. The two-sample t-test (for two independent groups) and the paired t-test (for matched samples) are likely the most used statistical techniques for comparing the differences between two samples if the data is normally distributed (Manfei et al., 2017)

The data analysis of the study by Abbasi et al. (2020), in which 382 students participated, was done using the independent t-test.

Table 11. *Analysis of Vocabulary Skills in the Pretest of the Experimental and Control Groups*

Group	*N*	*SD*	*Mean*	*t-comp*	*P-value*
Experimental	51	2.60	8.45	1.13	0.26
Control	51	3.00	7.82		

∝=0.05 level of significance

The mean in vocabulary skills of the experimental group (8.45) has a mathematical difference of 7.82 for the control group when subjected to a test. T-computed = 1.13 is obtained with a probability of 0.26, greater than ∝=0.05. Enough evidence warrants a claim that students in the experimental group had nearly the same vocabulary skill level as those in the control group at the time of the pretest.

The results imply that before the experiment began, the students' vocabulary skills in the experimental group were almost the same as those in the control group. Thus, the mathematical skills of subjects in the two groups showed almost the same level. The result is similar to the studies of Conception (2007) and Juario (2015). They contend that to ensure the validity of the experiment's findings, the two groups should have achieved comparable levels of academic success before the study's implementation. Similarly, Peñaredondo (2015) validated that the groups under experimental and control groups had the same level of performance before the conduct of the experiment.

When sample observations are gathered in pairs, usually before and following intervention in each study subject, the paired t-test is employed to evaluate the difference between the means of the two study groups (Vetter & Mascha, 2018).

Russ et al. (2017), Derrick et al. (2015), Derrick et al. (2016), and Toher and White (2018) suggest using the outcome for the difference between two random variables to provide reasonably simple tests for the comparison of means, proportions, and variances. In the extremes, the independent samples t-test or paired samples t-test is the default method for comparing means (Derrick & White, 2022).

Table 12. *Analysis of Recognition of Symbols Skills in the Pretest of the Experimental and Control Groups*

Group	*N*	*SD*	*Mean*	*t-comp*	*P-value*
Experimental	51	2.31	5.25	0.53	0.59
Control	51	2.46	5.00		

∝=0.05 level of significance

Comparing the mean of the symbol recognition skills of the two groups during the pretest, the experimental group obtained 5.25 while the control group had 5.0. The analysis revealed a t-computed value of 0.53 with a probability of 0.59, higher than ∝=0.05. There is enough evidence to claim that the means of the experimental and control groups do not differ significantly. It connotes that the level of mathematical skills of students in both groups in terms of recognition of symbols are the same.

The outcomes showed that the experimental group's performance was comparable to that of the control group preceding the experiment. As a result, the subjects' learning capacities in the two groups were nearly identical. In the study of Chiang, T. H., Yang, S. J., & Hwang, G. J. (2014) they emphasized that students' performance in experimental and control groups must point to the same level of knowledge. They added that students must be comparable as to their background in the subject before the experimental treatment to have better compatibility between the two groups.

Mathematical symbols can be divided into three groups, according to a condensed version of Serfati (2005), which was cited by Bardini and Pierce (2015), letters (including letter-like shapes from any language), other figures, and compound templates, which combine letters and figures into a two-dimensional shape. Combining the ideas mentioned earlier can result in symbolic statements that might be long or short.

If a sample's mean differs from a known average, it can be ascertained using a single sample t-test. To determine if there is a difference between the means of two comparable data sets, a 2-sample t-test is utilized. The test statistic for the t-test is determined by considering the number of samples, mean, and standard deviation. The critical value for the Student t-test, found in a t-test table, is 1.96 for an alpha of 0.05 in a data set including many samples. The z-test should not be performed if the sample size is less than 30 since it makes certain assumptions about the sample size during calculation. When the two groups' n and standard deviations are known, a two-sample t-test is best (Abdulazeez, 2014).

Generally, we do not meet the requirements for a z-test for two independent sample means when we need to assess the difference between two independent sample means. A z-test cannot be used in these situations. For independent samples, a two-sample t-test could be applicable (Volchok, 2020).

Table 13. *Analysis of the Mean Gain in Comprehension*

Group	*n*	*SD*	*Mean Gain*	*t-comp*	*P-value*
Experimental	51	1.84	3.20	5.87	< 0.001
Control	51	4.01	-0.43		

$\propto$=0.05 level of significance

The experimental group's mean gain score is higher than the control group's. Testing the difference between the mean gain scores resulted in t-computed = 5.87 with a probability less than 0.001, which is too small compared to the level of significance ($\propto$=0.05).

There is sufficient data to claim that the experimental group's mean gain is significantly greater than the control group's. It indicates that after being exposed to blended learning modalities, learners in the experimental group's comprehension skills have improved considerably compared to those in the control group. The results reveal that students in the experimental group can understand the concepts in Math 10 better than those in the control group. This outcome is comparable to the research done by Schechter et al. in 2015. They assert that treatment students demonstrated improvements that were considerably greater than those exhibited by control learners, particularly in their reading comprehension area.

It has been demonstrated that blended learning helps learners become more proficient readers. Consequently, blended learning is a viable solution to the issues of time constraints and the volume of material required for learning, thereby improving students' reading comprehension abilities (Rombot et al., 2020).

In the study of Santos and Atayan (2016), where the Experimental and Control groups were composed of 51 participants each (36 females and 15 males), for a total of 102, a t-test was used to prove the hypothesis for two independent samples.

The t-test can be used to compare the means of two samples. The data must be identically independent and normally distributed for the t-test. The paired t-test should be used instead of the two independent sample t-tests if the study design is the pre-post design and the result is a continuous variable (Yan et al., 2017).

Table 14. *Analysis of the Mean Gain in Computation*

Group	*n*	*SD*	*Mean Gain*	*t-comp*	*P-value*
Experimental	51	1.82	3.43	7.45	< 0.001
Control	51	3.75	-0.92		

$\propto$=0.05 level of significance

To ascertain whether the observed improvement in the experimental group's students' performance in computational skills is statistically significant, the mean gain in computation was assessed using the t-test. Moreover, the analysis revealed a highly significant difference between the two groups (t=7.45, p-value = 0.001<0.05).

The findings show a significant difference in the computational skill mean gain scores between the experimental and control groups. It suggests that learners in the experimental group outsmart learners in the control group when solving problems.

The results show that learners who adopted a blended learning approach performed better than those who just took classes using conventional learning methods. It implies that the blended learning strategy enhances students' computational skills.

Similar to the study of Warman (2021), he confirms that the outcome demonstrated following the treatments, the mean score of the experimental group was higher than the control group's mean score. This result proved that learners who employed the blended learning approach outside the classroom scored higher than those who did not.

By integrating the learning environment with the rapidly evolving Web technologies of today, we have blended learning yields more efficient advances in learning outcomes (Ceylan & Kesici, 2017)

The hypothesis was tested using the t-test in the study by Dadivas and Dalayap (2016), which included 60 participants.

The significance of the learning level difference between the experimental and control groups was ascertained using the t-test in the research conducted by Malantok and Dardo (2016), which had sixty participants. To find out how the mean gain scores of the two groups differed, the t-test was also applied.

Table 15. *Analysis of the Mean Gain in Vocabulary*

Group	*N*	*SD*	*Mean Gain*	*t-comp*	*P-value*
Experimental	51	2.61	4.22	4.80	< 0.001
Control	51	3.80	1.12		

∝=0.05 level of significance

The mean gain scores in vocabulary were evaluated using the t-test to see whether the observed improvement in the experimental group's learners' performance in vocabulary was statistically significant. Furthermore, based on the computed analysis results, it implies a highly significant difference between the two groups ($t = 4.80$, p-value = $0.001 < 0.05$) in terms of vocabulary.

The findings reveal that learners with blended learning modality obtained higher scores than those taught with conventional learning modality only. It implies that blended learning modality positively affects learners' vocabulary.

The findings are supported by Vasbieva et al. (2016), who noted that the students had achieved excellent learning outcomes towards the end of the blended design training program. The results show that the suggested blended learning technique enhanced the students' vocabulary achievement. The proposed blended learning strategy for teaching vocabulary was generally well received by the students, who preferred it to the more traditional classroom-based approach because it allowed them to study independently and at their own pace.

Language teachers worldwide are interested in the blended learning approach to teaching foreign languages. Blended learning incorporates various forms of technology-based education into a traditional face-to-face teaching and learning setting instead of pure e-learning, which is the sole use of electronic media for learning. Many higher education institutions use blended learning as an additional tool for helping students increase their vocabulary (Tosun, 2015).

Table 16. *Analysis of the Mean Gain in Recognition of Symbols*

Group	*N*	*SD*	*Mean*	*t-comp*	*P-value*
Experimental	51	2.19	3.86	6.28	< 0.001
Control	51	3.23	0.43		

∝=0.05 level of significance

The experimental group's mean gain score is 3.86, while the control group's mean score is 0.43. To determine whether the observed improvement in recognition of symbols among the experimental group's students is statistically significant, the mean gain scores of recognition of symbols were assessed using the t-test. The computed analysis results show a significant difference between the two groups ($t = 6.28$, p-value = $0.001<0.05$).

Based on the post-test results for the Control and Experimental groups, where the former was rated as low and the latter as average, it is evident that students who employed a blended learning modality performed better than those who solely relied on conventional teaching methods. The blended learning modality enhances the ability of learners to recognize symbols.

The outcome is comparable to the study of Ahmad and Change (2017). The experimental group's average value was significantly greater than the control group's because some students knew the meaning of the symbols that would be translated into verbal form before the final exam question.

When solving problems, the mathematical symbol is crucial for conveying the concept to others. The symbols themselves provide the foundation for communicating an idea. Their understanding of the mathematical symbols demonstrates the student's comprehension of the mathematical problem. Not comprehending a mathematical symbol can impede concept creation, comprehension, and communication. By simulating the circumstance for real-world use, symbols as a cognitive function aid a person in resolving a subjectively challenging situation (Putri, 2020).

Conclusion

The study's findings led to several conclusions. The pretest results revealed that the experimental group (EG) and the control group (CG) had nearly the same mathematical skills in comprehension, computation, vocabulary, and recognition of symbols. However, in the post-test, while the EG and CG still exhibited similar levels of mathematical skills in these areas, the EG showed higher post-test results. In contrast, some scores in the CG dropped in certain areas. Specifically, the EG's posttest mean scores exceeded their pretest mean scores, showing improvement across the board. In the CG, the post-test means for vocabulary and recognition of symbols were higher than the pretest, but scores for comprehension and computation declined, resulting in a negative mean gain. There was no significant difference between the EG and CG in their pretest performance across all areas. However, the mean gain scores between the two groups revealed statistically significant differences in comprehension, computation, vocabulary, and recognition of symbols, with the EG demonstrating greater progress in learning Math 10 competencies than the CG.

Based on the study's findings, it is recommended that the teaching intervention applied to the experimental group be further explored and potentially adopted as a strategy to enhance mathematical skills, particularly in comprehension, computation, vocabulary, and recognition of symbols. The significant improvement in the experimental group's performance suggests that this method could lead to better learning outcomes in Math 10 competencies. However, ongoing assessment and refinement of the approach are suggested to address areas where the control group experienced declines.

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