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Flipped Classroom Model in Teaching Functions for Stem Learners

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Abstract

This study was conducted to determine the effectiveness of Flipped Classroom Model in Teaching Functions for STEM Learners at Garcia College of Technology– Senior High School Department. This study used True Experimental Research design employing pre-test- post-test using random sampling method. There were two methods employed, namely: traditional instruction and flipped classroom. The result of the pre-test and post-test were compared. The same set of examination be administered among the two (2) groups. The subjects of this study were the 42 Grade 11 learners who were matched and paired according to their average grade in Grade 11 and sex. The study was managed in July 2024 to December 2024. The results showed that the average pre-test score of the learners using traditional classroom is classified as "Proficient". While, using flipped classroom is "Highly Proficient". The average post-test score of the STEM learners using traditional classroom is "Proficient" category while, using flipped classroom is "Highly Proficient". Further, there was statistically significant difference between the pre-test and post-test scores using traditional classroom and using flipped classroom. However, the difference between the pre-test and post-test scores of the traditional and flipped classroom groups is not statistically significant. It appeared that the STEM learners demonstrate an adequate understanding of the pre-test material using traditional classroom. Also, it demonstrates overall better performance among learners in the flipped setup. Results also suggest that traditional and flipped classroom method was effective in enhancing learners' understanding of the material and topic in Mathematics particularly in Functions.

Keywords: Flipped Classroom, Traditional Instruction, Teaching Functions, Stem Learners.

Introduction

According to effective educational tactics, clear explanations, and opportunities for practice have a major impact on academic success [1]. Results of the Program for International Student Assessment (PISA) 2022 revealed that nearly no pupils in the Philippines were top achievers in Mathematics, indicating that they achieved level 6 on the PISA Mathematics Test. The report signifies that 84% of Filipino pupils who took the test lacked sufficient mathematics skills when compared to other countries [2]. This necessitates a new or innovative approach in teaching Mathematics. However, there is a gap in the research regarding the effectiveness of utilizing the flipped classroom model as an intervention strategy to address difficulties.

Flipped classroom is an innovative instructional strategy where the teacher's role shifts from a traditional lecturer to a facilitator of learning, guiding students through problem-solving activities among others [3]. Added by Reyes and Santos this is where it becomes invaluable, offering the potential to bridge the gap, and it encourages active learning and critical thinking [4]. Moreover, in the study conducted by Cablas it appeared that in Guimaras State College, it demonstrated that the flipped classroom approach significantly improved students' problem-solving skills and performance in calculus [5]. Similarly, results in the study conducted by Gonzales at Cebu Technological University, it was revealed that the positive experiences of pre-service teachers with the flipped classroom approach, noting its effectiveness in

subjects like mathematics and its ability to engage students more actively in the learning process [6].

In Garcia College of Technology, Senior High School Department, the researcher observed during class that when students are asked of their recall of the previous lessons, they can easily forget and failed to remember important points of the previous lesson. Some cannot recall and even remember how to solve problem-solving when recapitulating prior lessons. The performance also of the class is low in terms of seatworks and learners have less engagement in boardworks or recitation.

With these, this study is intended to rigorously evaluate the impact of flipped classroom on student achievement in subject in General Mathematics at Garcia College of Technology in the District of Kalibo among Science, Technology, Engineering and Mathematics (STEM) Learners. The study sought to determine the effectiveness of flipped classroom model in teaching functions for STEM learners in General Mathematics of Grade 11 learners in Garcia College of Technology – Senior High School Department.

Specifically, this study sought to provide answers to the following questions:
1. What is the pre-test score of traditional and flipped classroom among STEM learners?
2. What is the post-test score of traditional and flipped classroom among STEM learners?
3. Is there a significant difference in the pre-test and posttest scores of traditional classroom among STEM learners?
4. Is there a significant difference in the pre-test and posttest scores of flipped classroom among STEM learners?
5. Is there a significant difference in the pre-test scores of traditional and flipped classroom among STEM learners?
6. Is there a significant difference in the posttest scores of traditional and flipped classroom among STEM learners?

Based on the problems formulated, the following hypotheses were presented:
1. There is no significant difference in the pre-test and posttest scores of traditional instructions among STEM learners.
2. There is no significant difference in the pre-test and posttest scores of flipped classroom among STEM learners.
3. There is no significant difference in the pre-test scores of traditional and flipped classroom among STEM learners.
4. There is no significant difference in the posttest scores of traditional and flipped classroom among STEM learners.

Literature Review

The Effectiveness of the Flipped Classroom Model in Teaching Functions Traditional Instruction

The traditional approach to Mathematical learning occurs when students are guided through a curriculum established Mathematical concepts by an expert educator/ teacher [7]. Traditional instruction is often referred to as teacher-centered instruction. According to Smith and Johnson it is a conventional pedagogical approach where the teacher plays a central role in the learning process [8]. Moreover, Brown discussed that it is a pedagogical model where students are passive learners, primarily engaged in listening, note-taking, and memorization of facts, under the guidance of the teacher [9]. In the other context, according to Jones traditional instruction is an established teaching method where standardized tests and examinations are the primary means of assessing student knowledge and comprehension [10].

Brown even emphasized that in this model, the teacher is typically responsible for content delivery [9]. Further, according to Smith and Brown in a traditional instruction, the teachers explain concepts and is responsible for classroom management and is characterized by a top-down teaching approach where students play a passive role, receiving information through lectures and textbooks, with limited interactive or student-led activities [11]. There were critics about the traditional classroom. Some of them argued that it may not effectively promote critical thinking and problem-solving skills [8]. As mentioned by Anderson some educators advocate for more learner-centered and innovative approaches that encourage active student engagement and accommodate diverse learning styles [12]. Another major criticism about the traditional classroom is the lack of engagement and interaction. It is believed that traditional classroom can lead to passive learning where students often become recipients of information rather than active participants in the learning process. In fact, Freeman discussed that it limits the development of critical thinking and problem-solving skills [13].

There were studies proving the positive effects of traditional classroom among learners and in the teaching-learning process. In the study of Flores and Kaylor they found that at risk students perform better, have higher student achievement and are more attentive in class when given direct instruction with traditional teaching methods [14]. Alzhanova-Ericsson provides evidence for a significant positive role of lecture attendance for students acquiring skills in Teaching and Learning Mathematics [15]. While attending lectures students receive situated tacit knowledge of the subject which is otherwise difficult, if not impossible, for them to obtain in a different way. Likewise, study conducted by Ali the result showed that there was significant difference between the effectiveness of traditional teaching method and problem-solving method in teaching of mathematics at elementary level [16].

Flipped Classroom

Basically, the flipped classroom reverses traditional teaching method. It differs by delivering instructional content outside of the classroom. It typically through done through video lectures, and using in-class time for interactive and collaborative activities [17]. In the case of a flipped classroom, the instructional content is usually delivered outside of class. In fact, it is often done through videos or readings. In this approach, it encourages students to engage more deeply with the material. It leads to active learning as a shift from passive reception of information.

The flipped classroom model has been widely applied primarily in K-12 education. However, it is also applied in higher education and professional development settings. McLaughlin implemented a flipped classroom approach in a health professions school [18]. This study proves the application of the flipped classroom in higher education. Based on their study, flipped classroom method demonstrating improved student engagement and learning outcomes. It was also found by Tune that it enhanced student performance in graduate-level physiology courses using the flipped model [19].

Studies have shown that the flipped classroom had advantages in enhancing student learning outcomes. One of those studies is a meta-analysis by Hew and Lo. It was found in their study that flipped classrooms significantly improve student performance in comparison with the traditional teaching methods [20]. Moreover, it was reported higher levels of student engagement, motivation, and satisfaction. Another study that supports this result was a study conducted by O'Flaherty and Phillips. They observed that in flipped classrooms, students can apply concepts during interactive class activities [21]. With this, it promoted a deeper understanding and retention of knowledge. There was also research which indicates that the flipped classroom fosters a more engaging and collaborative learning environment. One of those studies is the study of Rotellar and Cain which it appeared in their study that flipped classroom encourages students to take responsibility for their learning, which then lead to increased participation and collaboration during class [22]. It was supported by Lage that by allowing students to review instructional materials at their own pace, it accommodates diverse learning styles and needs [23].

Difference in the Test Score of the Learners Using Traditional Classroom

One of the critical aspects of education is the determination of the academic performance of the students in Mathematics. Understanding how learners obtained acceptable performance using traditional instruction is essential. While traditional methods can effectively convey information and ensure content mastery, they may limit deeper engagement and application of knowledge in real-world contexts. Traditional classroom is criticized because teaching approach requires innovation, learner-centered approaches that accommodate diverse learning styles, and approach that can promote active student participation.

There are numerous researches examining the effectiveness of traditional instruction and is compared to other teaching methodologies. One of those researches in the study of Smith where it appeared that academic performance of learners under traditional instruction has produced mixed findings [24]. Moreover, as noted by Johnson and Smith some studies have suggested that traditional instruction can be effective in conveying information. It can also facilitate learning where learners are often performed well on standardized tests. In the study of Brown and Jones for instance, applying the traditional classroom, results of the study found that learners tend to focus on rote memorization and may result having them a hard time and they struggle to apply knowledge in real-world contexts [25]. It even resulted in surface-level learning. As a result, it may not adequately prepare students for complex problem-solving tasks. It is also supported by Smith and Davis stating the one-size-fits-all approach of traditional instruction may not cater to the diverse learning styles and needs of all students, and that some learners may thrive in traditional classrooms [26]. Other that these, others may struggle to engage with the material or feel disengaged. This situation leads to lower academic performance. In the application of traditional classroom, the significant difference in test scores can be influenced by individual student characteristics. In fact, Jones and White mentioned that the advanced learners may thrive in traditional instruction environments, leading to higher scores [1].

The traditional classroom method proved that it can be beneficial for ensuring that students acquire essential mathematical skills and understand core concepts. In the study of Hiebert and Grouws it showed that traditional teaching methods is effective in mathematics education, particularly in developing procedural fluency and foundational knowledge [27]. It is also supported by the study by Clark and Linn wherein it appeared that the traditional classroom benefits for mastering basic mathematical skills [28]. It was also found that students who received structured, direct instruction showed significant improvements in their mathematical performance compared to those who experienced less structured teaching approaches considering that the direct instruction in delivering complex mathematical concept is often praised for its clarity and efficiency.

As a support, Rosenshine highlighted that effective direct instruction involves clear explanations, guided practice, and regular feedback [29]. These approaches contribute to improved student outcomes in Mathematics. It also emphasized the importance of well-structured lessons that build on students' prior knowledge and provide opportunities for repeated practice. Another study by Wu supports the same idea [30]. The study highlights the importance of traditional methods in mathematics education. In this study, it was argued that traditional approaches are crucial for building a strong mathematical foundation. Considering that this approach emphasized the systematic teaching of mathematical procedures and concepts, this is critical in the said condition The study likewise suggests that while traditional methods may not be as engaging as interactive approaches, it is still essential for ensuring that students develop the necessary skills and knowledge to succeed in mathematics.

Difference in the Test Score of the Learners using Flipped Classroom

The flipped classroom has demonstrated that learners in often achieve higher test scores compared to those in traditional classrooms. One of those is in the study of McLaughlin where they have implemented a flipped classroom model in a health professions school. In their study, it was found that students performed significantly better on assessments of their understanding and application of medical concepts. The said improvement was attributed to increased engagement with pre-class materials. It is also associated to more interactive learning experiences during class time. Another study that supported the impact of flipped classroom was a meta-analysis study conducted by Hew and Lo. The findings of their study reported a consistent positive effect (including higher test scores and improved retention of knowledge) of flipped classrooms on student learning outcomes.

The result supports the notion that the flipped classroom model indeed enhances academic achievement as this approach promotes active learning and deeper understanding of course content. In the study of Tune. where they applied the flipped classroom model in graduate-level physiology courses, they have observed higher exam scores among students compared to traditional lecture-based courses. It was also highlighted in the study that the flipped approach allowed students to engage more deeply with complex physiological concepts and apply them in problem-solving scenarios.

Based on the researches, it is then identified several factors contribute to the observed improvements in test scores using

flipped classroom model. One of those includes increased student engagement and active participation in class activities. It also includes personalized learning experiences and the opportunity for self-paced learning through pre-class materials [33]. These elements are particularly relevant in teaching Business Mathematics, where understanding mathematical concepts in business contexts is crucial for effective decision-making and problem-solving. The same result appeared in the study of Bishara where the findings indicated that among students who studied under the active teaching method, the improvement that occurred in the scope of mathematics achievements was distinctly greater than the improvement in scope of mathematics achievements occurring among students studying under the traditional teaching method [31]. Similarly, Noreen and Rana concluded that students taught through activity based teaching performed better in post-test [32]. It is recommended that in future Mathematics may be taught with activities at elementary level. Mathematics kit containing material for activities may be provided to Mathematics teachers.

Theoretical Framework

This study was anchored on the theory of Constructivist Learning

Theory by Vygotsky and Kolb's Experiential Learning Theory. Constructivist learning theory, as conceptualized by Lev Vygotsky, is a prominent educational framework that highlights the importance of social interaction and cultural context in the cognitive development of individuals (Vygotsky, 1978). In the context of flipped classroom, traditional lecture-based instruction is being shifted to outside the classroom, typically through videos or readings. With this approach, it allows in-class time to be dedicated to active learning activities aligning with Vygotsky's emphasis on learning through social interaction. The Kolb's Experiential Learning Theory is based on the idea that learning is an active, continuous process and that individuals construct knowledge through direct engagement with their environment. Kolb (2015) defined learning as "the process whereby knowledge is created through the transformation of experience". In this framework, the researcher explored how this approach can be applied to Business Mathematics education in teaching Functions in Garcia College of Technology among Grade 8 STEM learners. It focused with its theoretical underpinnings, relevance to the subject, and expected impact on student achievement.

The schematic diagram of the study is reflected in figure 1.

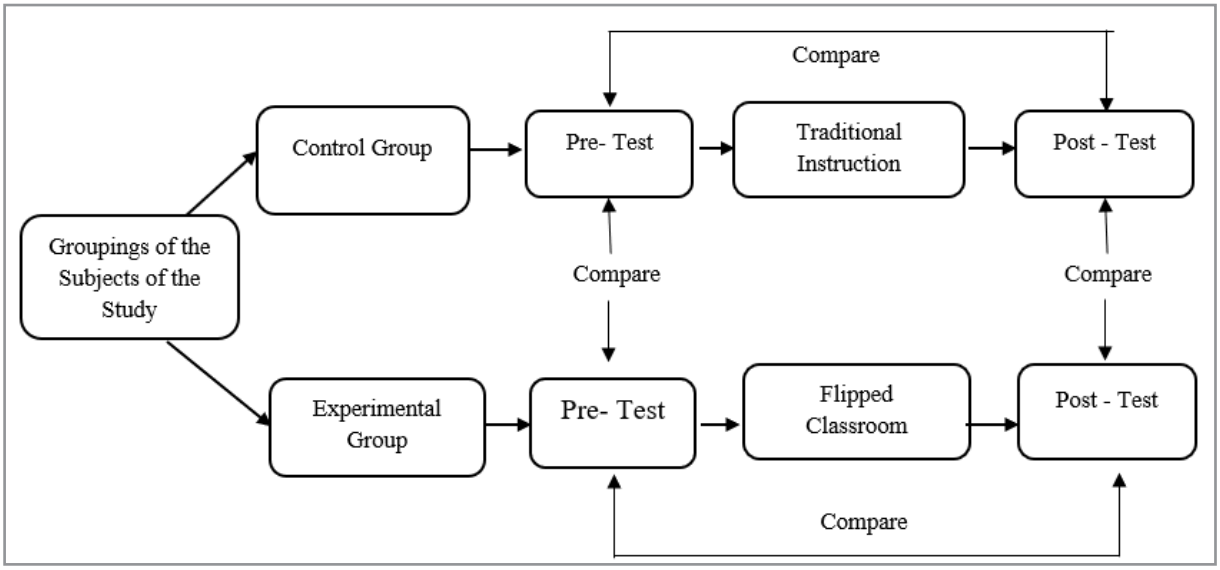

Figure 1: The Schematic Diagram of the Study

Figure 1 shows that the students were be selected from the population and were match-paired according to First Quarter grade. A total of forty-two (42) learners were chosen where one group of 21 learners were randomly assigned as the control group while the other as the experimental group of 21 learners.

Initially, both groups were given a pretest to determine students' Mathematics performance. One group had a traditional instruction while the other group had flipped classroom. There were two (2) tests – pre-test and post-test employed in the study. The both of the pre-test and post-test scores of those groups having traditional instruction were compared and similarly, it applies to the group having flipped classroom.

Additionally, the pre-test results of the learners in traditional instruction is compared with the pre-test results in flipped classroom were also compared; and the post-test results of the learners in traditional instruction is compared with the post-test results in flipped classroom were also compared.

Methodology

Research Design

This study employed a quasi-experimental design, specifically the utilization of pre-test and post-test. In this design, the respondents are assigned to either the experimental group or the control group. There were two methods employed, namely: traditional instruction and flipped classroom. There were two (2) groups from the Grade 11 learners where one (1) group had traditional instruction while the other group had flipped classroom. The result of the pre-test and post-test were compared. The same set of examination was administered among the two (2) groups. The study was conducted at Garcia College of Technology – Senior High School Department, Kalibo, Aklan. The subjects of this study were the 42 selected Grade 11 learners who were matched

and paired according to their average grade in Grade 11 and sex. There were 42 students in total as subject of the study where one group had 21 learners assigned in control group and another 21 learners were assigned to experimental group. This study was conducted for six (6) weeks interventions exploring the traditional and flipped classroom instruction. The study was managed in July 2024 to December 2024.

The data were gathered using a researcher-made test administered in the pre-test and post-test of both the control and experimental groups. The pre-test and post-test results of both the experimental and control groups were analyzed using frequency counts, mean, and percentage. To determine the significant differences between tests scores of learners who were exposed in traditional and flipped classroom, Wilcoxon Signed-Rank Test was used.

Findings and Discussions

Pre-Test Score of Traditional and Flipped Classroom among STEM Learners

Table 2 shows the pre-test score of traditional classrooms among STEM learners. As indicated in the table, only a small proportion of the learners (9.50%) scored in the "Advanced" category while, about a quarter of the learners (23.80%) achieved a score classified as "Highly Proficient". Further, approximately 19% of the learners fell into the Proficient category, indicating an acceptable level of competence. Nearly half of the learners (47.60%) scored in the Low Proficient category. This suggests they have below-average performance and may struggle with the pre-test material. Generally, the average score of the learners is 15.19, which is classified as "Proficient". This indicates that, on average, the class demonstrates an adequate understanding of the pre-test material among STEM learners using traditional classroom.

The results of the study imply that a minimal number of students demonstrated a highly superior understanding of the pre-test content. There were students as well who showed strong competency and preparedness in the content assessed by the pre-test. Students are also meeting the expected level of understanding for this stage of learning.

In the present study, it appeared that 23.80% of learners in the "Highly Proficient" category demonstrate strong competency, but this group represents only a portion of the class. The result of the present study aligns with the findings of the study by Estrada which showed that traditional classrooms can support competent learners [33]. However, it may not adequately challenge them to move beyond basic proficiency, particularly in complex subjects like Mathematics. The results further suggest it may not be enough to elevate them to advanced levels of understanding though, traditional instruction may work for students with foundational knowledge. It also appeared in the study that the overall pre-test score of learners in traditional classroom is proficient. This finding is similar with those of Ruhl. They have reported that traditional instructional methods often lead to students achieving average performance levels [34]. But, such may not able to help learners develop deeper problem-solving and critical thinking skills that are necessary for mastering complex mathematical concepts.

Table 2: Pre-Test Score of Traditional Classroom among STEM Learners.

Category	Frequency	Percentage
Advanced	2	9.50
Highly Proficient	5	23.80
Proficient	4	19.00
Low Proficient	10	47.60
Mean = 15.19;		
Description = Proficient		

Table 3 shows the pre-test score of flipped classroom among STEM learners. The table shows a small proportion of learners (9.50%) achieved the "Advanced" category, demonstrating exceptional mastery of the pre-test content. On the other hand, nearly a quarter of the learners (23.80%) achieved the "Highly Proficient" level, showcasing strong understanding and readiness while, the majority of the learners (66.70%) scored in the "Proficient" category, a significant increase compared to the traditional classroom. These results suggest a solid understanding of the material at a satisfactory level. When taken as a whole, it appeared that the average score of 18.19 is categorized as "Highly Proficient", which is notably higher than the mean score of the traditional classroom (15.19), categorized as Proficient. The result demonstrates overall better performance among learners in the flipped classroom setup.

It appeared in the results of the present study that a larger proportion of students (23.80%) achieved the "Highly Proficient" level. This reflects a strong competency and preparedness in the content. Moreover, this result is consistent with studies of Liu that show flipped classrooms can help learners develop a more robust understanding of the material [35]. Flipped classroom encourage self-directed learning and collaboration. In addition, according to Liu there were several studies have shown that flipped classrooms often lead to improved student outcomes, particularly in Mathematics subjects. This is because the approach focused on the interactive and student-centered learning which leads to affect learners' performance. O'Flaherty and Phillips noted that flipped classrooms provide more opportunities for active learning and problem-solving, which can contribute to higher achievement levels.

Table 3: Pre-Test Score of Flipped Classroom among STEM Learners.

Category	Frequency	Percentage
Advanced	2	9.50
Highly Proficient	5	23.80
Proficient	14	66.70
Mean = 18.19;		
Description = Highly Proficient		

Post-Test Score of Traditional and Flipped Classroom among STEM Learners

Indicated in Table 4 is the post-test score of traditional and flipped classroom among STEM learners. As reflected in the table, there were four (4) learners, or 19.00% of the class, achieved the "Advanced" category. These learners demonstrate an exceptional understanding and mastery of the post-test material. Another 19.00% of learners (4 students) scored in the "Highly Proficient" category which indicates a strong comprehension and above-average performance. More so, the largest group, comprising 8 learners or 38.10% of the class, achieved the "Proficient" category. These students met the expected level of competency and understanding. While, five (5) learners, or 23.80% of the class, remained in the "Low Proficient" category, showing below-average performance and difficulty in fully grasping the material. Generally, the average score of the class is 17.38, which falls under the Proficient category. This result indicates an overall satisfactory level of understanding among the learners.

The largest group (38.10%) achieved the "Proficient" category. These learners have met the expected level of competency and understanding. This is consistent with the typical distribution found in many traditional classrooms, where most students perform at an acceptable level but may not fully engage with or understand the deeper aspects of the material [36]. However, according to Wiliam it may also indicate that traditional methods tend to provide students with the basic skills necessary for academic progress without fostering deeper, more comprehensive learning [37]. In this study, it appeared that the overall average score of 17.38, categorized as "Proficient". The results of the study suggest that the class, on the whole, achieved a satisfactory level of understanding. While this may appear positive, the distribution of scores points to the limitations of traditional teaching methods in reaching all learners effectively. Studies by O'Flaherty and Phillips have shown that traditional classrooms, while effective for some, do not always foster deep learning or allow for personalized instruction, potentially contributing to the gaps seen in the Low Proficient category.

Table 4: Post-Test Score of Traditional Classroom among STEM Learners.

Category	Frequency	Percentage
Advanced	4	19.00
Highly Proficient	4	19.00
Proficient	8	38.10
Low Proficient	5	23.80
Mean = 17.38;		
Description = Proficient		

Indicated in Table 5 is the post-test score of flipped classroom among STEM learners. As indicated in the table, two (2) learners, representing 9.50% of the class, achieved the "Advanced" category, demonstrating exceptional mastery of the post-test material. Reflected in that table that almost half of the class (47.60%) scored in the "Highly Proficient" category. This result indicates a strong understanding of the material and superior competency levels. Additionally, there were nine (9) learners, or 42.90% of the class, fell into the "Proficient" category. This appeared that meeting the expected level of competency for the post-test material. Generally, the average score of the class is 20.00 which is categorized as "Highly Proficient". The said result signifies that the flipped classroom approach raised the overall performance level of the class to an above-average standard. It was found in the result of the present study that nearly half of the learners (47.60%) scored in the "Highly Proficient" category.

The result shows that a significant portion of the class demonstrated strong understanding and superior competency in Mathematics. Moreover, this suggests that flipped classrooms promote active learning and student-centered teaching. This allows and helps students to develop a deeper understanding of the material. The said result is supported by the studies by O'Flaherty and Phillips which showed that flipped learning can improve student engagement. When it happens, it leads to better comprehension and higher achievement levels. Moreover, result also showed that the overall average score of 20.00, categorized as "Highly Proficient". This result shows a substantial improvement in the learners' performance compared to traditional classroom settings (where the average score was lower). There was a study which showed that the flipped classroom not only increases academic performance but also enhances the student satisfaction and motivation. In the study of Kim it was noted that by shifting from a passive learning model to one that encourages active engagement and personalized learning [38].

Table 5: Post-Test Score of Flipped Classroom among STEM Learners.

Category	Frequency	Percentage
Advanced	2	9.50
Highly Proficient	10	47.60
Proficient	9	42.90
Mean = 20.00;		
Description = Highly Proficient		

Difference in the Pre-Test and Post-Test Scores of Traditional Classroom among STEM Learners

Presented in Table 6 is the difference in the pre-test and post-test scores of traditional classroom among STEM learners. As presented, the average score of the learners in the traditional classroom before the intervention was 15.19, which is categorized as "Proficient". Also, the average post-test score improved to 17.38, which is still categorized as "Proficient", though closer to the Highly Proficient range. In addition, the p-value of .000 indicates the statistical significance of the difference between the pre-test and post-test scores. Based on the statistical analysis, the null hypothesis (Ho), which typically states that there is no significant difference between the pre-test and post-test scores, is rejected. The p-value is less than the level of significance of .005 level of significance resulting to reject the null hypothesis. The traditional classroom setup led to a statistically significant increase in the mean score, suggesting that the method was effective in enhancing learners' understanding of the material.

The result of present study was supported by various studies. According to Bates studies on the effectiveness of traditional teaching methods suggest that while these methods may not always lead to drastic improvements. These studies can still be effective in enhancing students' comprehension when applied consistently and with proper engagement. Muir discussed that in traditional classrooms, teachers generally use direct instruction and structured learning environments, which can result in incremental improvements in students' understanding over time [39]. Black and Wiliam have emphasized that regular formative assessments and teacher guidance in traditional settings can enhance student performance by providing timely support and addressing individual learning needs. Additionally, despite its limitations, traditional classroom teaching is still considered a crucial element of academic achievement, particularly when the focus is on creating a structured learning environment that encourages students' active participation [40, 41].

Table 6: Difference in the Pre-Test and Post-Test Scores of Traditional Classroom among STEM Learners.

Category	Mean	p-value	Decision
Pre-Test Scores of Traditional	15.19		
Post-Test Scores of Traditional	17.38	.000 ^{s}	Reject Ho

^{s}significant at .05 level of significance
^{ns}not significant at .05 level of significance

Difference in the Pre-Test and Post-Test Scores of Flipped Classroom among STEM Learners

Presented in Table 7 is the difference in the pre-test and post-test scores of flipped classroom among STEM learners. As presented, the mean pre-test score of learners in the flipped classroom was 18.19, categorized as "Highly Proficient". After the intervention, the mean post-test score increased to 20.00, maintaining the "Highly Proficient" category. It can also be gleamed that the p-value of .000 indicates a statistically significant difference between the pre-test and post-test scores. The null hypothesis (Ho), which posits that there is no significant difference between pre-test and post-test scores, is rejected. The p-value is less than the level of significance of .005 level of significance resulting to reject the null hypothesis. This means that the flipped classroom method resulted in a statistically significant increase in mean scores, with learners moving closer to the Advanced category in the post-test.

The result of the present study is supported by the study of He and Zhu. In their study, they had highlighted that flipped learning promotes self-directed learning and allows students to take ownership of their learning process [42]. There were also studies that showed flipped learning typically involved interactive and hands-on activities which leads to improved academic performance. In the study by Koo for instance, it showed that learners in flipped classrooms had greater engagement and deeper understanding of content compared to their peers in traditional lecture-based settings [43]. Similarly, in the study of Bergmann and Sams they had highlighted how flipped learning fosters active learning environments [44]. Students are more involved in the learning process and can benefit from collaborative problem-solving during in-class activities.

Table 7: Difference in the Pre-Test and Post-Test Scores of Flipped Classroom among STEM Learners.

Category	Mean	p-value	Decision
Pre-Test Scores of Traditional	18.19		
Post-Test Scores of Traditional	20.00	.000 ^{s}	Reject Ho

^{s}significant at .05 level of significance
^{ns}not significant at .05 level of significance

Difference in the Pre-Test Scores of Traditional and Flipped Classroom among STEM Learners

Shown in Table 8 is the difference in the pre-test scores of traditional and flipped classroom among STEM learners. As shown in the table, the mean pre-test score for learners in the traditional classroom setup was 15.19, categorized as "Proficient" while, the mean pre-test score for learners in the flipped classroom was 18.19, categorized as "Highly Proficient". Furthermore, the p-value of .076 indicates that the difference between the pre-test scores of the traditional and flipped classroom groups is not statistically significant. The null hypothesis (Ho), which states that there is no significant difference between the pre-test scores of the two groups, is accepted. The p-value is greater than the level of significance of .005 level of significance resulting to accept the null hypothesis. In the present study, it appeared that while the flipped classroom group had a slightly higher mean pre-test score (18.19 compared to 15.19), the difference is not statistically significant.

The result of the study accepts the null hypothesis. This posits that there is no significant difference between the pre-test scores of the two groups. This simply indicates that both groups started with a similar level of proficiency. This further suggests that prior learning experiences or backgrounds of the learners did not favor one teaching approach over the other before the intervention. Consequently, the results suggest that because the groups were statistically similar at the beginning, any improvements seen in post-test scores can be more confidently attributed to the teaching method (flipped vs. traditional) rather than pre-existing knowledge differences. One of the studies which had the same result was the study by Roach where it showed that there were no significant differences in pre-test scores were found between students in traditional classrooms and flipped classroom before the intervention [45]. This result suggests that learners in both traditional classroom and flipped classroom entered the course with similar prior knowledge. Similarly, it appeared in the results from a study by Bergmann and Sams that the flipped classroom model did not necessarily lead to higher initial scores but instead provided an enriched environment for deeper engagement and learning throughout the course.

Table 8: Difference in the Pre-Test Scores of Traditional and Flipped Classroom among STEM Learners.

Category	Mean	p-value	Decision
Pre-Test Scores of Traditional	18.19		
Post-Test Scores of Traditional	20.00	.000 [s]	Reject Ho

[s]significant at .05 level of significance
[ns]not significant at .05 level of significance

Difference in the Post-Test Scores of Traditional and Flipped Classroom among STEM Learners

Shown in Table 9 is the difference in the post-test scores of traditional and flipped classroom among STEM learners. As shown in the table, the mean post-test score for learners in the traditional classroom was 17.38, categorized as "Proficient" while, the mean post-test score for learners in the flipped classroom was 20.00, categorized as "Highly Proficient". In addition, the p-value of .111 indicates that the difference in post-test scores between the traditional and flipped classroom groups is not statistically significant. The null hypothesis (Ho), which states that there is no significant difference between the post-test scores of the two groups, is accepted. The p-value is greater than the level of significance of .005 level of significance resulting to accept the null hypothesis. In the present study, results appeared that the flipped classroom group achieved a higher mean score (20.00) compared to the traditional classroom group (17.38), suggesting a potential advantage for the flipped approach.

In this study, the results showed the acceptance of the null hypothesis. This posits that there is no significant difference between the post-test scores of the two groups. Further, this implies that although the flipped classroom group achieved a higher mean score, this difference could be attributed to chance or other external factors, rather than being a direct result of the flipped classroom model. The finding of the present study aligns with research by Zainuddin and Halili. It was found in their study that while flipped classrooms had positive effects on learning experiences and the motivation. Moreover, the impact on academic achievement was variable and sometimes not statistically significant, depending on the nature of the subject and the students' prior knowledge. Similar result appeared in the study by Strayer and Al-Zahrani. Their study emphasized that while flipped classrooms could enhance learners' engagement, critical thinking, and problem-solving skills among others, these improvements did not always translate into significantly higher academic scores. This also happened when learners were already performing well in traditional settings.

The results of the present study resulted to accept the null hypothesis. The study then suggests that the flipped classroom approach did not lead to significantly higher academic performance compared to the traditional approach, at least in terms of post-test scores. Although the mean of the post-test scores of the learners in traditional and flipped classroom appeared to have difference, the individual scores and its match might have minimal difference when compared. Moreover, the academic scores were not significantly different, the flipped classroom may still provide other educational benefits. According to Zainuddin and Halili flipped classroom resulted to improved engagement, motivation, critical thinking, and problem-solving skills.

Table 9: Difference in the Post-Test Scores of Traditional and Flipped Classroom among STEM Learners.

Category	Mean	p-value	Decision
Pre-Test Scores of Traditional	18.19		
Post-Test Scores of Traditional	20.00	.000 [s]	Reject Ho

[s]significant at .05 level of significance
[ns]not significant at .05 level of significance

Conclusions

On average, the STEM learners demonstrated an adequate understanding of the pre-test material using traditional classroom. They have prior knowledge of the subject matter to be taught. Also, it demonstrated overall better performance among learners in the flipped classroom setup.

The STEM learners have an overall satisfactory level of understanding of the Mathematics topic using traditional classroom. The result also signifies that the flipped classroom approach raised the overall performance level of the STEM learners to an above-average standard. The learners in the flipped classroom have enough understanding in the subject matter taught [46].

The traditional classroom setup led to a statistically significant increase in the mean score, suggesting that the method was effective in enhancing learners' understanding of the material and topic in Mathematics particularly in Functions. The traditional classroom set-up is therefore effective in enhancing the learners' understanding in the lesson. The flipped classroom method resulted in a statistically significant increase in mean scores, with learners moving closer to the Advanced category in the post-test. It suggests that the method was effective in enhancing learners' understanding of the material and topic in Mathematics particularly in Functions. It appeared that while the flipped classroom group had a slightly higher mean pre-test score with the traditional classroom, the difference is not statistically significant. Simply put, using the traditional and flipped classroom yield to a no difference pre-test result and are both effective in teaching Mathematics. Further, it means that students in both groups may have had comparable levels of mathematical proficiency before the intervention, resulting in no significant difference in pre-test scores. Since students have not yet engaged in the instructional approach, their initial performance is independent of the teaching strategy [47]. They have almost equivalent level of prior knowledge. It appeared that while the flipped classroom group had a slightly higher mean post-test score with the traditional classroom, the difference is not statistically significant. Simply put, using the traditional and flipped classroom yield to a no difference post-test result and are both effective in teaching Mathematics. This further implies that both groups might have started with similar levels of understanding in Mathematics before the intervention, meaning that neither teaching method had an advantage at the beginning. Likewise, considering that Mathematics is cumulative, prior knowledge alone may not show significant variations between the groups until after instructional interventions.

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