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Flipped Teaching Instruction: Aid In Enhancing Graphing of Polynomials

[a]Lynn A. Rondina,[b]Ginlo S. Manatad,[c]Angel A. Prado,[d]Lelibeth B. Atabay,[e]Micheal E. Monda,[f]Mary Joy P. Beronas, [g]Jorizal A. Tabon, [h]Jenabie G. Mapula, [i]Jed G. Bonite, [j]Eld Jun O. Lacostaña,[k]Michelle O. Serafin, [l]Dr. Marnel M. Bullo, [m]Dr. Richard C. Ching, [n]Lester V. Gonzales,[o]Emelita May B. Abarca

Cataingan Municipal College, Cataingan, Masbate Philippines

A B S T R A C T :

This research sought to assess how effective flipped teaching methods are in enhancing the capability of Grade 10-Gardenia students at Cataingan National High School to graph polynomial functions. Students frequently viewed this topic as abstract and complex , which hindered their mastery using conventional teaching approaches. To address this issue, the research utilized a flipped classroom approach, enabling students to engage with instructional videos and digital materials at home while in-class time was dedicated to teamwork, supervised practice, and interactive problem-solving exercises. A quasi-experimental design was implemented, featuring a control group educated through conventional methods and an experimental group instructed with flipped teaching techniques. Data were gathered via pretests and post-tests to evaluate students' academic performance, worksheet tasks to examine conceptual understanding and problem-solving abilities, and a student perception survey to collect feedback on engagement and learning experiences. The findings showed that students in the experimental group exhibited significant improvement in their ability to graph polynomial functions compared to the control group. The Wilcoxon Signed-Rank Test yielded a p-value of 0.040, indicating a statistically significant variation in the post-test scores of students who underwent flipped teaching methods. Learners additionally noted improved motivation, heightened involvement, and increased self-assurance in their independent study. In summary, the flipped teaching method demonstrated success in enhancing student performance and engagement in mathematics. The approach promoted a better comprehension of complex subjects and fostered student-centered learning . Consequently, it is advisable for teachers to utilize flipped classroom techniques, especially in areas or topics considered challenging, to improve educational outcomes and promote the growth of independent learning abilities.

Keywords: flipped classroom, worksheets, quasi-experimental design, perception survey, polynomial function

1. Introduction

Mathematics teaching often presents challenges for students, particularly when dealing with complex and abstract topics such as graphing polynomial functions. These difficulties are frequently associated with the conceptual nature of mathematical concepts and the cognitive effort required to understand them. Traditional teaching methods, primarily centered on the instructor, may not effectively address these challenges, as they often create passive learning environments in which students have limited opportunities for engagement and understanding. Research has shown that conventional lecture-based teaching methods might hinder students' ability to thoroughly understand mathematical ideas. Freeman et al. (2014) conducted a meta-analysis demonstrating that active learning strategies significantly improve student performance in science, engineering, and mathematics. Their study suggests that employing active learning methods could lead to better academic outcomes compared to traditional lectures, emphasizing the need for instructional approaches that actively involve students in their learning.

To overcome the limitations of traditional teaching methods, innovative educational strategies such as Flipped Teaching Instruction (FTI) have emerged. The flipped classroom model involves delivering instructional materials outside of the classroom—typically through videos and online tools—allowing classroom time to prioritize collaborative tasks and problem-solving activities. This approach aims to foster a more engaging and student-centered learning environment. Bishop and Verleger (2013) highlighted the potential of the flipped classroom to enhance student engagement and academic outcomes by promoting active participation in classroom activities.

At Cataingan National High School, learners have faced considerable challenges in graphing polynomial functions, indicating a need for improved teaching methods. To address this issue , the adoption of FTI was seen as a way to enhance students' comprehension and skills in this area . By shifting direct instruction to activities before class and using class time for interactive learning, FTI aims to provide students with a better understanding of mathematical concepts and improve their problem-solving abilities . The implementation of FTI aligns with current educational trends that emphasize

the importance of active learning and student engagement . Research has demonstrated the effectiveness of the flipped classroom approach in boosting academic achievement and fostering a deeper understanding of the material. For instance , Ruiz-Palmero et al. (2021) found that the flipped classroom model positively influenced students' academic performance and satisfaction in mathematics learning. Therefore , the execution of FTI at Cataingan National High School has the potential to address the challenges students face in graphing polynomial functions while enhancing their overall educational experience.

1.1 Statement of the Problem

This action research examined the effectiveness of flipped teaching instruction in enhancing the performance of Grade 10-Gardenia at Cataingan National High School. By using innovative materials, some mathematics skills of the students were observed to have improved. Further, it examined how worksheets helped and supported students' progress and development. Specifically, the study examined the performance level of Grade 10- Gardenia before and after the intervention. This study aimed to determine whether the students' performance in mathematics, particularly in graphing polynomial functions, significantly improved after the implementation of the intervention.

2. Methods

2.1 Research Design

In this study a qualitative and quantitative research desiged are both used to examined the effects of flipped teaching instruction on students' performance in graphing polynomial functions. Involving two groups a quasi-experimental design was used, a control group that continued with the traditional lecture-based instruction, and an experimental group that experience flipped classroom instruction. Using pre- test and post- test, students were assesed on their performance to examined if there was improvement.Pretest was conducted before the intervention to assess students' prior knowledge of graphing polynomial functions.In order to develop flipped teaching instruction , the students in the experimental group participated the intervention that lasted for one week. These included video lessons and worksheets to reinforce concepts. Through the intervention teacher-researchers facilitated these sessions and documented students' performance and behavior.

Student perception survey was also conducted to gather qualitative data on their thoughts and experiences. After the intervention, a post-test was administered using the same assessment tool to measure any improvement in students' performance. As a result of this mixed-method approach, the study was able to measure and assess both the effectiveness and the reception of the flipped teaching strategy. This methods follows Bergmann and Sams (2012), who introduced flipped classroom idea, it state that by recording lectures and assigning them as homework, teachers can free up class time.

2.2 Data Sources

The primary data sources for this study were 37 Grade 10 students from Section 4-Gardenia, who served as the experimental group, and Section 5-Hyacinth, who served as the control group of Cataingan National High School, located in Cataingan, Eastern District, School Division of Masbate, Philippines. In the experimental group, there were 11 males and 26 females, while in the control group, there were 15 males and 22 females. The experimental and control groups took both pre- and post-test assessments to identified whether there was a difference between the implemented flipped teaching instruction and the traditional way of teaching. If the focus was only on the experimental group where the innovation was implemented.Students from Section 4-Gardenia served as experimental group took both pre- and post-test assessments to measure if there was a significant difference in students' performance before and after the implementation of flipped teaching instruction. To assess how will the flipped teaching strategy improved student's scores on the pre-test and post-test, a quantitative analysis was examined to determine the effectiveness of the intervention. Normality testing of the data was done using Shapiro-Wilk test. Since the data did not follow the normal distribution, the Wilcoxon Signed- Rank Test was used.According to Ghasemi & Zahediasl (2012), the Shapiro-Wilk test is a reliable method for assessing normality in small sample sizes, and non-parametric alternatives such as the Wilcoxon Signed-Rank Test are appropriate when data are not normally distributed. Descriptive analysis was used to evaluate students' thoughts and behavior after the intervention using the student perception survey. By analyzing , it was confirmed that the flipped teaching instruction innovation had significantly improved students' performance in graphing polynomial functions. These observations provided further evidence of the students' progress before, during, and after the intervention.

2.3 Research Procedure

The study involved 37 Grade 10 students from Section 4-Gardenia of Cataingan National High School, with 11 male and 26 female students participating. The researchers obtained permission from the school head before beginning the study in the school setting to ensure official permission and support (Bullo, et.al , 2021).To enable regular and successful delivery, the researchers were oriented on the goals and procedures of intervention in the study (Bullo, et.al, 2021). Flipped teaching instruction was designed to strengthen students' understanding of graphing polynomial functions for Grade 10 students. Instructional strategies such as video lessons and worksheets help to raised conceptual understanding and students participation. Experts confirmed the content accuracy and instructional appropriateness of these materials by means of validation and evaluation (Bullo, et.al, 2021). Ethical considerations were noted through, including securing informed consent from parents or guardians, preserving and maintaining confidentiality, and emphasizing voluntary participation (Bullo, et.al, 2021).The researchers carefully handled and conducted all assessment tools to guarantee the dependability of the findings. Data from the pretest and post-tests were To protect the identities of the participants and guarantee objective processing,

anonymization should precede analysis (Bullo, et.al , 2021).The researchers used the non-parametric statistical technique Wilcoxon Signed-Rank Test to examine the differences between pretest and post-test results given the non-normal distribution of the data. Compare and analyze the flipped teaching approach using scores.

3. Results and Discussion

3.1 Assessment of the Data Normality Distribution

The pretest and post-test scores were collected from 37 Grade 10-Gardenia students, who served as the experimental group used to assess the efficacy of the intervention in increasing mathematics performance of students, especially in graphing polynomial functions. Taken prior to the pretest Intervention provided a baseline against which the prior understanding of graphing polynomial functions of the students was assessed. After the intervention, the post-test conducted to establish whether any improvement occurred. Table 1.0 shows the results of the Shapiro-Wilk normality test; this data was used to ascertain whether the pretest and post-test score distributions were normal. This study found p-values of 0.024 for the pretest and 0.162 for the post-test**.**The findings indicated that the pretest scores were not normally distributed, while the post-test scores did not show a significant departure from normality.

Due to the non-normal distribution of the pretest results, a non-parametric statistical test was deemed appropriate. The Wilcoxon Signed-Rank Test was chosen as the suitable method for analyzing the paired data. Being non-parametric, it did not require normality assumptions, making it ideal for comparing the pretest and post-test scores. This enabled a reliable evaluation of the flipped teaching instruction

Table 1.0
Shapiro-Wilk Normality Test Results for Pretest and Post-test Scores of Grade 10-Gardenia(Experimental Group)

Variables	N	S-W	P-value	Interpretation
Pretest	37	0.931	0.024	Not Normally Distributed
Post-test	37	0.957	0.162	Normally Distributed

The pretest and posttest scores were collected from 37 Grade 10-Hyacinth students, who served as the control group to evaluate whether the traditional way of teaching continued to enhance students' performance in mathematics, specifically in graphing polynomial functions.

Table 1.1 presented the Shapiro-Wilk Test for normality, which confirmed that both sets of scores followed a normal distribution, with the p-value of 0.090 in the pretest and a p-value of 0.453 in the posttest. As a result, a paired t-test was conducted to examine whether a significant difference existed between the two sets of scores.

Table 1.1
Shapiro-Wilk Normality Test Results for Pretest and Post-test Scores of Grade 10-Hyacinth(Control Group)

Variables	N	S-W	P-value	Interpretation
Pretest	37	0.949	0.090	Normally Distributed
Post-test	37	0.972	0.453	Normally Distributed

3.2 Mathematics Performance of Grade 10 - Gardenia Students Before and After the Implementation of Flipped Teaching Instructions

According to the Wilcoxon Signed-Rank Test results presented in Table 2 (P = 0.040), the post-test and pretest were substantially different. This outcome suggested the positive impact of the intervention in enhancing students' learning, especially in graphing polynomial functions. Since the P-value was being less than 0.05, the observed improvement in mathematics performance was statistically significant. These results aligned with the emphasizing that flipped teaching could enhance student engagement and improve conceptual understanding in mathematics by Bergman and Sams (2012). The data further suggested that the flipped teaching methods supported students to understand difficult mathematical concepts. The improvement observed, as evidenced by their higher post-test results, emphasized the possibilities of this approach of teaching to improve personal learning results. This study showed how flipped learning encouraged a more interactive and student-centered learning environment in the classroom.
Reflecting on the positive outcomes, it may be inferred that flipped teaching not only improved academic performance but also encouraged the growth of learning independence and confidence in tackling mathematical problems. Therefore, flipped teaching turned out to be a useful approach in instruction, especially in improving learning in polynomial functions.

Table 2
Mathematics Performance of Grade 10 - Gardenia Students Before and After the Implementation of Flipped Teaching Instructions

Variables	N	S-W	P-value	Interpretation
Pretest-Posttest	37	133	0.040	Statistically Significant

If the researchers focused only on the results of Grade 10-Gardenia, who served as the experimental group and received the intervention, it indicated that there was a positive impact on the students' learning progress, particularly in graphing polynomial functions. This indicated that the implementation of Flipped Teaching Instruction enhanced mathematical skills and understanding of the students specifically in graphing polynomial function. Based on the gathered data, it was revealed that before the intervention, students scores were certainly low but significantly improved after the intervention. This presented that there was a notable difference between students performance before and after the intervention. By implementing flipped teaching instruction students became more motivated, prepared, and confident in solving problems, as they had access to lesson materials in advanced and used classroom time for practice and clarification. This demonstrated that the academic performance of the students in pre-intervention and post-intervention differed significantly because students had advanced access to lesson materials and utilized class time for explanation and practice, students who received the intervention became more confident in solving problems. This observation supported the findings of Egara and Mosimege (2023), who found out that students who exposed in flipped teaching instruction showed greater interest and performed better academic performance compared to students who received traditional methods.

The study emphasized that the flipped classroom model enhanced student engagement and understanding by allowing students to interact with instructional materials at their own pace and utilize classroom time for collaborative problem-solving. Although the data gathered indicated a significant improvement in student performance before and after the intervention, several factors still had to be taken into consideration. This included behavioral responses ot the students, their ability to manage and follow instructions effectively and the lack of important resources such as gadgets, internet access and limited time of conducted intervention period, which served as a challenge for the researchers to managed the students behavior, interest, and attentions, these challenges were aligned with the study of Bond (2021), who presented that while flipped teaching instruction could increase students participation and interaction it also mentioned challenges such as students skipped classes because of being unprepared for pre-class learning tasks. The study emphasized the importance of addressing these issues to fully realized the benefits of Flipped Teaching Instruction. On the other hand, if the researchers focused on the results of Grade 10- Hyacinth, who serve as the control group and were taught using traditional way of teaching, it also showed a positive impact on their learning progress even without exposed for the intervention. This suggested that despite of being not exposed to flipped teaching strategy, students were still acquired learning effectively under the traditional way of teaching. It showed that the traditional approach remained a valid and structured way of delivering lessons, especially when facilitated well by the teacher. Supporting this, Yilmaz and Antun (2018) conducted a meta-analysis examining the effects of traditional teaching methods on students' success in mathematics, focusing on geometry and number learning among middle school students.

The study found out that traditional way of teaching had a positive effect on students achievement when it comes to mathematics, reinforcing the validity of conventional instructional approaches in mathematics education. Flipped teaching instruction and the traditional way of teaching indicated similarities regarding on students academic performance, specially in graphing polynomial functions. This indicated that while both methods were effective the success of either of these approaches depend on factors such as students readiness, lesson design and classroom implementation. Thus, combination of both strategies may resulted to unique, effective, and most balanced effective approach to education. This conclusion was supported by the study of Algami and Lortie-Forgues (2022), which evaluated the effectiveness of Flipped Teaching Instuction on mathematics proficiency and self efficacy on Saudi Arabia. The study found out that there is no significant difference between the academic performance of students who had been taught using Flipped Teaching approach and traditional methods. Suggesting that both instructional strategies could be equally effective when properly implemented. These integrated findings suggested that both flipped teaching instruction and traditional teaching methods had their merits in mathematics education. Educators might consider a hybrid approach that forced the strengths of both strategies to enhance student learning.

3.3 Mathematics Performance of Grade 10-Hyacinth Without the Exposure to the Intervention

The analysis of the pretest and post-test scores of Grade 10-Hyacinth learners in Mathematics, who did not undergo the implementation of the intervention, showed no statistically significant improvement. Based on the results of the paired sample t-test, as shown in Table 3, there was no significant difference between the pretest and post-test scores ($t = -0.657$, $p = 0.516$). Since the p-value was greater than 0.05, this indicated that the changes in scores were likely due to random variation and not the result of any targeted instructional method. This suggested that, while conventional instruction provided a foundation, it might have benefited from complementary strategies to further enhance learning outcomes in topics such as graphing polynomial functions.

Marzano (2003) indicated that instructional strategies affected student learning, especially when these strategies were organized, well-planned, systematically applied in the classroom, and properly evaluated (Akdeniz, 2016, p. 62).

The results implied that although some students may have shown individual progress, the overall instructional method was not sufficient to significantly

enhance performance in graphing polynomial functions. Reflecting on these outcomes, it could be concluded that without the integration of innovative and learner-centered approaches, such as flipped teaching, improvements in mathematical understanding and achievement remained minimal. This conclusion aligned with the findings of Bergmann and Sams (2012), who advocated for flipped learning as a means to maximize and ensure deeper comprehension of complex topics by allowing more interactive and personalized classroom experiences.

Table 3
Mathematics Performance of Grade 10-Hyacinth Without the Exposure of the Implementation

Variables	N	S-W	P-value	Interpretation
Pretest-Posttest	37	-0.657	0.516	Not Statistically Significant

3.4 Students' Perception of the Flipped Teaching Strategy

The data presented in Table 4 highlighted the results of the Respondents' Perception Survey conducted among Grade 10-Gardenia students regarding the implementation of Flipped Teaching Instruction. The overall weighted mean was 3.08, which fell under the verbal interpretation "Agree." This indicated that, overall, the students had a positive perception of the flipped teaching approach. Among the indicators, Indicator 10 obtained the highest mean score of 3.48, interpreted as "Strongly Agree," suggesting that this specific component of the intervention was the most well-received by the learners.

However, it was worth noting that although many students strongly agreed with the aspect under Indicator 10, Indicator 8 recorded the lowest mean score of 2.71. While this still fell under the "Agree" category, it indicated that this area was perceived slightly less favorably.

Despite these variations in individual ratings, the majority of responses were positive. In contrast, the relatively lower rating for Indicator 8 suggested that some aspects of the flipped instruction might have required further improvement. While not as highly rated, it was still accepted by the students.

Thus, the findings supported the conclusion that the flipped teaching method had been effective overall, contributing positively to students' experiences and shaping favorable attitudes toward learning mathematics.

Table 4
Respondents Perception Survey
Adopted from Bullo et al., (2021)

Indicators	Weighted Mean	Rank	Interpretation
1. The flipped learning helped me understand the lesson about graphing of polynomial.	3.05	6.5	Agree
2. The flipped classroom concept helps me to work in the contents of the course at my own pace.	2.90	9	Agree
3. The presentation of the concepts using flipped teaching is clear and fitted to my needs.	3.05	6.5	Agree
4. The flipped classroom helps me to refresh my previous knowledge.	3.17	2.5	Agree
5. I feel more motivated in flipped learning.	3.02	8	Agree
6. The flipped classroom concept helps me to improve my self-learning skills.	3.12	4	Agree
7. I believe this method guided me toward better understanding of the content.	3.17	2.5	Agree
8. Flipped teaching helps me to know what to expect in the exam.	2.71	10	Agree
9. Flipped learning helps me to received additional support for my studies.	3.10	5	Agree
10. Generally, I am happy and satisfied with this learning experience.	3.48	1	Strongly Agree
TOTAL	**3.08**		**Agree**

4. Conclusion

The findings of this study demonstrated that the implementation of flipped teaching instruction significantly improved the performance of Grade 10-Gardenia students in graphing polynomial functions. The use of pre-recorded videos and interactive worksheets allowed students to study the content at their own pace and come to class better prepared for deeper discussions and the application of concepts. This approach promoted active learning, improved classroom engagement, and resulted in statistically significant gains in the post-test scores. On the other hand, the traditional teaching method used in the control group (Grade 10-Hyacinth) did not yield significant improvements in student performance. While this approach provided a structured learning environment, it lacked the flexibility and student-centered features of the flipped classroom. The results highlighted the limitations of conventional methods when used alone for teaching abstract mathematical concepts like polynomial functions.

Students' perceptions of the flipped classroom were generally positive. Most of them agreed that the approach helped them understand the lesson better, refreshed their prior knowledge, and improved their self-learning skills. These responses indicated that students appreciated the opportunity to learn

independently and collaboratively apply concepts in class. However, challenges such as a lack of internet access, device limitations, and varying levels of student motivation were noted. Addressing these limitations is crucial for maximizing the benefits of flipped instruction. In conclusion, the flipped teaching strategy proved to be a valuable instructional method for enhancing student performance in mathematics. While both flipped and traditional methods have their own strengths, a hybrid approach that incorporates the structure of traditional teaching along with the flexibility of flipped learning could provide a more balanced and effective learning experience for students.

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