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MATHEMA TIC-TAC-TOE: AN INTERVENTION TO ENHANCE POLYNOMIAL-SOLVING SKILLS AMONG STUDENTS IN KAPALONG NATIONAL HIGH SCHOOL

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ABSTRACT

The purpose of this study is to evaluate the impact of the Mathema Tic-Tac-Toe intervention on students' skills in solving polynomial problems. Specifically, the study aims to determine the significant difference between students' pretest and post-test scores. A pre-experimental research design was utilized to assess the intervention's effectiveness. Data were collected from 76 students in Grades 8 and 10 at Kapalong National High School, selected through purposive sampling. Pre-test and post-test assessments were used for data gathering. The findings revealed a substantial improvement in scores, with the mean percentage score increasing from 15.5% (Very Low) before the intervention to 61.14% (Average) after the intervention. The t-value obtained was -22.19, indicating a substantial difference in the scores before and after the intervention or treatment related to solving polynomials. This large negative t-value suggests a strong effect of the treatment on the students' ability to solve polynomials. This significant improvement in scores indicates a highly positive impact of the Mathema Tic-Tac-Toe intervention on students' ability to solve polynomial problems. The results suggest that the intervention is effective in enhancing students' performance in this area, demonstrating a strong and beneficial effect on their Mathematical skills. The teacher may use this intervention in their mathematics classes to improve the problem solving skills of the students in polynomials.

KEYWORDS*: Action Research, Intervention, Polynomial Problem Solving Skills, Mathema Tic-Tac-Toe*

INTRODUCTION

Polynomials are a fundamental concept in mathematics, laying the groundwork for more advanced algebraic concepts and applications. Polynomial is not as complicated as it sounds, because it is just an algebraic expression with several terms. The inability to solve polynomials poses a significant barrier to students' progress in mathematics. It hinders their understanding of algebraic concepts, such as factoring, simplifying expressions, and solving equations, which are essential for further mathematical studies. Moreover, difficulties with polynomials can lead to a decline in confidence, motivation, and overall interest in mathematics (Deziel, 2018).

In Thailand, secondary students have certain misconceptions regarding polynomials and m mistakes when adding and subtracting polynomials, as well as wrongly displaying signs in difficult situations. Such findings were also discovered in interviews with math teachers who had been teaching seventh graders for more than five years. Children also have certain misconceptions about addition, subtraction, multiplication, and

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division, and it has been recognized that children must develop critical thinking skills in mathematics (Monrat et al., 2022).

In the Philippines, according to Amper's study (2023), the competence in addition and subtraction have the lowest number of students with correct answers. This means that the ability in addition and subtraction of polynomials is the least learned of the six competencies in Grade 7 Mathematics. This is reinforced by a research conducted by Soso (2020) on the capacity of Grade 7 students to solve equations and problems involving polynomial functions. Based on DepEd Memorandum # 160 s, this means that the learners require a higher level of proficiency on this competency.

In local settings, problems in solving polynomials is prevalent specifically in Kapalong National High School, a significant number of students exhibit a lack of knowledge and skills when it comes to tackling problems involving polynomials. They encounter considerable difficulties in basic operations such as addition, subtraction, multiplication, and division of polynomials. Moreover, errors often arise during the process of performing and evaluating expressions. According to a mathematics teacher at the school, a lot of in-needs and challenged students particularly struggle when confronted with mathematical equations containing variables like 'x' and 'y,' as well as when simplifying expressions involving two or more terms. These challenges have a direct impact on their overall achievement in the subject. Given that polynomials are a fundamental part of the curriculum from grades 7 to 10, these difficulties significantly affect students' comprehension and success in various mathematical topics.

The researcher's motivation for conducting this study stemmed from its critical societal significance. The urgency to investigate this matter was underscored by the widespread prevalence of insufficient polynomial-solving skills across educational institutions, not just locally or nationally, but on a global scale. This issue persisted and demanded attention due to its profound impact on students' academic performance and achievements in mathematics. Neglecting this problem perpetuated its existence and continued to adversely affect students' mathematical proficiency, consequently leading to diminished overall performance in the subject. Therefore, pursuing this study became imperative as it held the promise of enhancing students' proficiency in polynomial problem-solving.

There is no enough study that explore problem-solving skills in polynomial of the students and enhance problem solving skills of the students. The previous study conducted by Soso (2020), San Vicente National high School titled "The Competency of Grade 7 Students in Solving Problems Involving Polynomial Function and Equation" which focuses in determining the competency of Grade 7 in solving problems involving polynomial functions and equation using the descriptive research design. Another study conducted by Chonchaiya et al., (2022), titled "Identifying Common Errors in Polynomial of 8th Grade students" which focuses on finding the errors of the student in solving polynomial problems. However, this study uses Pre-experimental design to determine the effectiveness of Mathema Tic-Tac-Toe intervention in enhancing the skills of student in solving polynomia problems. This research uses math game-based intervention (Tic-tac-toe) to enhance problem solving skills of the student in polynomials and also make the student enjoy while solving problems. This makes the intervention effective because it is not boring unlike to the traditional approached like lecturing, paper-and-pencil test which cannot provided interactive learning experience. Tic-tac-toe – a game-based approach provides engaging and interactive experience to the students while learning the concept of solving polynomials.

RESEARCH OBJECTIVES

In this study, it was emphasized what would happen to the pretest and post-test of the study. The following were the set objectives:

1. To determine the level of performance in solving polynomials among students.
2. To determine the level of performance in solving polynomials among students during the post- test.
3. To determine if there was a significant relationship between the pretest and post-test scores of the students.

RESEARCH HYPOTHESIS

The null hypothesis was tested at 0.05 level of significance stated that there is no significant relationship between the pre-test and post-test of the students in Kapalong

METHODOLOGY

The design of this study was pre-experimental because the researcher wanted to measure the effect of the Mathema Tic-Tac-Toe intervention on the polynomial problem-solving skills of the students. A pre-experimental design is an investigative approach aimed at determining whether there is an effect of the studied variable. It refers to the conceptual framework within which the experiment is conducted. The most important criterion is that the design be appropriate for testing the particular hypothesis of the study (Ary et al., 2021).

In addition, in this study, the participants came from Kapalong National High School, a secondary public school located in Maniki, Kapalong, Davao del Norte. In this school, many students had experience difficulties in solving problems, especially polynomials. A purposive sampling was used in the selection of the research participants by which, the total number of participants in this study was 76 students from grades 8 and 10, who took a pre-test, received the intervention, and took a post-test.

The data gathered from the pretest and post-test underwent tabulation. The complete questionnaires were collected by the researchers and subsequently entered into a Microsoft Excel spreadsheet for data encoding. The statistician was granted confidential permission to perform calculations, create tables, and

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analyze the data with utmost discretion. The results of the tabulation served as the basis for evaluating the effectiveness of the intervention in polynomial problem-solving skills. The findings guided potential modifications or improvements in the intervention strategies to further enhance teaching practices.

Moreover, this study adapted one questionnaire from the study of Marpa (2019). The research instrument underwent pilot testing and also Kuder Richardson 20 (KR20) was used to determine the reliability of the test. The r-value of 0.91 using KR20 formula indicates that the research instrument has very high reliability. The test consisted of 30 algebraic questions, divided into six sections:

1. Classification of algebraic expression according to the number of terms.
2. Classification of algebraic expression according to the degree.
3. Addition and Subtraction of algebraic expression.
4. Translations.
5. Multiplication of algebraic expressions.
6. Division of algebraic expressions.

In assessing polynomial problem-solving skills for the total score, the folalowing criteria were used:

Table 1
Range of Mean Percentage

Range of Mean Percentage	Descriptive Level	Interpretation
91-100	Very High	If the measures described in the polynomial problem solving skills of the students is outstanding.
76-90	High	If the measures described in the polynomial problem solving skills of the students is very satisfactory.
61-75	Average	If the measures described in the polynomial problem solving skills of the students is satisfactory.
51-60	Low	If the measures described in the polynomial problem solving skills of the students is fairly satisfactory.
0-50	Very Low	If the measures described in the polynomial problem solving skills of the students did not meet the expectation.

RESULTS

Presented in this chapter are the result or data obtained in the study. The chapter presents the data on the level of performance in solving polynomials among student in pretest; the level of performance in solving polynomials among student in post test; and significant difference of the pretest and post-test scores of the students.

Presented in **Table 2** are the results of the pretest, indicating the performance levels of 76 students in solving polynomial problems. The overall mean score is 12.4 with the equivalent mean percentage score of 15.5, which indicates very low performance by the students in the pretest. The highest score is 28 with the frequency of 2, while the lowest scores is 2 with the frequency of 3. The most frequent score is 12 which has 9 frequency. In the pre-test no one passed the test.

Table 2
Mean Average of the Score in Pretest

PRETEST SCORES	FREQUENCY	PERCENTAGE
2	3	3.95 %
3	5	6.58 %
4	4	5.26 %
5	1	1.32 %
6	4	5.26 %
7	3	3.95 %
8	2	2.63 %
9	1	1.32 %
10	2	2.63 %
11	5	6.58 %
12	9	11.84 %
13	5	6.58 %
14	6	7.89 %
15	8	10.53 %

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16	4	5.26 %
18	3	3.95 %
19	2	2.63 %
20	1	1.32 %
22	3	3.95 %
26	1	1.32 %
27	2	2.63 %
28	2	2.63 %
Total	**76**	**100.00%**
Overall Mean Score		**12.40**
Mean Percentage Score		**15.5**
Description		**Very Low**

Presented in **Table 3** are the results of the post test, indicating the performance levels of 76 students in solving polynomial problems. The overall mean score is 48.91 with the equivalent mean percentage score of 61.14, which indicates average performance by the students in the post-test. The highest score is 77 with the frequency of 2, while the lowest scores is 32 with the frequency of 1. The most frequent score is 35, 37, 38, 39 and 44 which has 4 frequency. In the 80 items test the passing score is 60 and there are 17 student who passed the test.

After a month of receiving the MATHEMA TIC-TAC-TOE intervention, which focuses on game- based polynomial problem-solving, the post-test result was 61.14, indicating an average level of performance. This represents an almost fourfold increase from their pre-test performance, demonstrating that the students now possess satisfactory skills in solving polynomials, including addition, subtraction, multiplication, division, translation, and identification. This suggests that the intervention positively impacted their polynomial problem-solving skills.

Table 3
Mean Average of the Score in Post-test

POST-TEST SCORES	FREQUENCY	PERCENTAGE
32	1	1.32 %
33	1	1.32 %
34	7	9.21 %
35	4	5.26 %
36	3	3.95 %
37	4	5.26 %
38	4	5.26 %
39	4	5.26 %
40	1	1.32 %
41	3	3.95 %
42	2	2.63 %
44	4	5.26 %
45	2	2.63 %
48	2	2.63 %
49	2	2.63 %
51	3	3.95 %
53	1	1.32 %
54	1	1.32 %
55	2	2.63 %
56	1	1.32 %
57	3	3.95 %
58	2	2.63 %
59	2	2.63 %
61	3	3.95 %
63	1	1.32 %
65	1	1.32 %
67	2	2.63 %

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68	2	2.63 %
71	1	1.32 %
72	2	2.63 %
73	1	1.32 %
74	1	1.32 %
75	1	1.32 %
77	2	2.63 %
Total	**76**	**100.00%**
Overall Mean Score		**48.91**
Mean Percentage Score		**61.14**
Description		**Average**

Presented in **table 4** was the result of the significant difference between the pretest and post- test scores, t (75) = -22.19, p<.001. Since the p-value (<.001) is lesser than the level of significance (α=0.05), the null hypothesis was rejected in this context. A paired t-test was conducted to determine the level of performance in solving polynomials among 76 students during pretest.

The t-value obtained was -22.19, indicating a substantial difference in the scores before and after the intervention or treatment related to solving polynomials. This large negative t-value suggests a strong effect of the treatment on the students' ability to solve polynomials. It indicates that there is a significant improvement in the students' scores from the pretest to the post-test, with the post-test scores being much higher on average. Overall, a t-value of -22.19 in this context indicates a highly significant and positive impact of the intervention or treatment on the students' performance in solving polynomials. The p-value was found to be less than 0.001, with a p-value of less than 0.001, the results are considered statistically significant at the 0.05 significance level. This implies that the difference in performance from pretest to post-test is unlikely to have occurred by chance. The mean of the pre-test is 12.40 (with the equivalent mean percentage score of 15.5) that has a description of very low. These measure describe that the polynomial problem-solving skills of the student did not meet the expectation.

Table 4
Mean Average of the Score in Post-test

Type of Test	N	df	Mean	SD	t-value	P-value	Decision $\alpha = 0.05$
Pre-Test	76	75	12.40	6.50	-22.19	**< .001**	**Significant**
Post-Test	76		48.91	13.34			

The mean of the post-test is 48.91 (with the equivalent mean percentage score of 61.14) with the description of average. These measure describe that the polynomial problem- solving skills of the students is satisfactory. In the pretest the standard deviation is 6.50, it means that the values in the pretest are relatively close to the mean of the data set. This indicates that there is less variability or spread among the values in the pretest. On the other hand, the standard deviation in the post-test is 13.34, it means that the values in the post-test are more spread out from the mean compared to the pretest. This suggests that there is more variability among the values in the post-test data set.

In addition, the result also revealed that the level of performance of the 76 students in post-test was 61.14, indicating a high level of performance. This indicates that the polynomial problem solving skills of the students is satisfactory. This improvement indicates that the students' problem-solving skills had reached a satisfactory level, meeting the basic expectations for polynomial problem-solving.

Moreover, a t-value of -22.19 in this context indicates a highly significant and positive impact of the intervention or treatment on the students' performance in solving polynomials. This found out that there is a significance difference between the pre-test and post-test scores of the students. This indicates that the Mathema Tic-tac-toe intervention was effective in enhancing students' problem-solving skills in polynomials. This significant difference demonstrates the effectiveness of the Mathema Tic-tac-toe intervention. The intervention successfully enhanced the students' abilities to solve polynomial problems, moving their performance from very low to average. This suggests that the educational strategy implemented through Mathema Tic-tac-toe had a

CONCLUSION

The study result revealed that the level of performance of the 76 student in pre-test is 12.40 (mean percentage score of 15.5) which classified as very low. This indicates that the polynomial problem-solving skills of the students did not meet expectations. This low performance underscores the students' initial lack of proficiency in this area.

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positive impact on the students' learning outcomes, highlighting its potential as a valuable tool in mathematics education.

RECCOMMENDATION

Based on the findings of this study, several recommendations can be made to further enhance the learning experience and effectiveness of teaching polynomial problem-solving skills, and potentially other areas of mathematics. First, it is highly recommended that teachers incorporate the Mathema Tic-Tac-Toe game into their mathematics classes. This game-based approach has proven to significantly improve students' abilities to solve polynomial problems, making the learning process both engaging and effective. By integrating this interactive method into regular classroom activities, teachers can create a more dynamic and stimulating learning environment.

Additionally, conducting further action research to evaluate the effectiveness of Mathema Tic-Tac-Toe in other mathematical topics, such as trigonometry, statistics, and calculus, is essential. This research can determine whether the positive outcomes observed in polynomial problem-solving can be replicated across different areas of mathematics. Furthermore, exploring the potential of this game-based intervention in other subjects beyond mathematics could provide insights into its broader educational benefits and versatility.

Moreover, educational institutions should consider providing professional development for teachers on how to effectively implement game-based learning strategies like Mathema Tic-Tac-Toe. This training can equip educators with the necessary skills and knowledge to utilize these innovative methods to enhance student learning outcomes. Additionally, further studies should be encouraged to explore and document the long-term impacts of such interventions on student performance and engagement in mathematics and other subjects.

Furthermore, fostering a collaborative learning environment where students can engage in peer-to-peer learning while using Mathema Tic-Tac-Toe can also be beneficial. This approach can promote teamwork, communication, and collaborative problem-solving skills, which are valuable beyond the classroom.

Lastly, given the successful implementation of the Mathema Tic-Tac-Toe game in teaching polynomial problem-solving, it suggests its potential as a valuable educational tool. Expanding its use and conducting further research can contribute to a more effective and enjoyable learning experience for students across various subjects and educational levels.

The recommendations based on this study emphasize the importance of integrating innovative game-based learning approaches into mathematics education, conducting rigorous research across different mathematical topics, providing adequate professional development for teachers, and fostering collaborative learning environments. These efforts aim to enhance student engagement, improve learning outcomes, and explore the broader educational benefits of such interventions.

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