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MATHEMAGIC SQUARE PUZZLE: AN INTERVENTION IN IMPROVING BASIC OPERATION SKILLS ON INTEGERS

Kervin Cyril L. Cusit[1], Johniel T. Angteg[2], Jade H. Cellacay[3], Faith D. Arabis[4], Ivy Joy L. Altizo[5]

[1]ORCID No.: 0009-0008-5234-6499
Student Researcher, Kapalong College of Agriculture, Sciences and Technology, Maniki, Kapalong, Davao del Norte, Philippines
[2]ORCID No.: 0009-0006-76061X
Student Researcher, Kapalong College of Agriculture, Sciences and Technology, Maniki, Kapalong, Davao del Norte, Philippines
[3]ORCID No.: 0009-0004-4951-6531
Student Researcher, Kapalong College of Agriculture, Sciences and Technology, Maniki, Kapalong, Davao del Norte, Philippines
[4]ORCID No.: 0009-0007-2684-1616
Student Researcher, Kapalong College of Agriculture, Sciences and Technology, Maniki, Kapalong, Davao del Norte, Philippines
[5]ORCID No.: 0009-0001-7728-3585
Student Researcher, Kapalong College of Agriculture, Sciences and Technology, Maniki, Kapalong, Davao del Norte, Philippines

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ABSTRACT

Basic operation skills on integers are crucial for building a strong mathematical foundation. However, many students in early schooling show poor performance in these fundamental skills. To address this issue, this study aims to assess the effectiveness of using the MatheMagic Square Puzzle as an intervention to enhance integer operation skills among Grade 7 students at Kapalong National High School. The study had a total of 114 students, and it employed quantitative research with a one-group pre-test post-test design and purposive sampling. Results revealed that the overall mean score level of basic operation skills on integers of the experimental group in the pre-test is very low, which is interpreted as it did not meet the expectation. While results in the post-test revealed from the overall mean is average, which is interpreted as satisfactory. Results indicate significant difference between the pre-test and post-test of the experimental group shows that there is a significant difference in the performance levels of the experimental group before and after the intervention. The study revealed a significant improvement in students' ability to solve basic operations on integers. This improvement proved the effectiveness of the MatheMagic Square Puzzle intervention and proved it to be a valuable tool in mathematics education, specifically for teaching integers. The researchers suggest implementing MatheMagic Square Puzzle widely for teaching basic integer operations in Grade 7 due to its effectiveness in improving student performance. They also suggest studying its effectiveness across various grades and mathematical concepts to expand its impact.

KEYWORDS: *MatheMagic Square Puzzle, Basic Operation on Integers, Intervention, Grade 7 students, Philippines*

INTRODUCTION

"Operation integers" encompasses fundamental arithmetic operations like addition, subtraction, multiplication, and division involving whole numbers, including positive and negative integers, and zero, while excluding fractions and decimals. Assessing the "performance of students" in this context involves gauging their proficiency in applying these operations. However, challenges arise as students commonly encounter issues and misconceptions during integer operations, stemming from factors like carelessness, inadequate foundational knowledge, surface-level understanding, and external limitations. Teachers face hurdles in addressing these challenges due to constraints such as limited time, large class sizes, and insufficient resources for effectively diagnosing and correcting students' errors. Effectively navigating these complexities is crucial for fostering a solid grasp of integer operations among students (Cetin, 2019).

In Indonesia, students face difficulties with integers and integer operations in their mathematics learning. Research has shown

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that the primary issue many students encounter is understanding negative numbers, largely due to their abstract nature. Furthermore, students' experiences at primary school significantly influence their understanding of this concept. It has been suggested that a brief and insufficient introduction to negative numbers at primary school leads to students struggling with integer operations due to their inadequate learning of this topic. Preliminary interviews with three mathematics teachers from different junior secondary schools revealed that integer operations present challenges for both students and teachers. Various studies have indicated that many students continue to make errors when performing integer operations. It has been argued that students generally do not encounter difficulties when learning integer arithmetic operations. However, problems arise when negative numbers are involved in integer operations (Fuadiah & Suryadi, 2019).

In the Nueva Ecija Philippines, Mathematics is a mandatory subject in both basic and higher education. However, many students wish it could be optional or even removed from the curriculum, as it often poses a barrier to completing their academic requirements and graduating on time. It is commonly agreed that many students struggle with the concept and principles of integers. This struggle contributes to the country's overall low performance in Mathematics. In high school, students often have difficulty solving verbal problems, partly due to their low retention of past lessons, especially on integers. Understanding integers is crucial as it serves as a foundation for learning other mathematical concepts (Tanghal, 2020).

Moreover, the study will develop an understanding of using the MatheMagic Square Puzzle as an intervention in improving basic operation skills on integers. In the context of a rapidly evolving global landscape, mathematical literacy, specifically the comprehension of integers and their operations, is indispensable for individual and societal progress. Nevertheless, a significant number of students grapple with these concepts, thereby impeding their overall scholastic advancement and future prospects. This research endeavors to address this critical issue by investigating the efficacy of math puzzles as a potential pedagogical tool. By augmenting students' proficiency in basic integer operations, we can bolster their mathematical literacy, thereby enhancing their academic performance and future career trajectories. However, this study will be conducted at Kapalong National High School, a local high school situated in a local setting in the province of Davao del Norte. This will be conducted through paper survey questionnaires answered by Grade 7 students at the same school. Further, the study will be conducted so as to determine the result or status of the issue and to monitor the improvement of students' basic operation skills on integers through an intervention and drafts that will be made based on the data that will be acquired and measured.

Furthermore, the researchers conducted this study as it is highly relevant and important to society, and it is beneficial to the program in the institution since it provides insightful data that offers a viewpoint on improving basic operation skills on integer with MatheMagic square puzzle as an intervention. Moreover, this research could potentially contribute to the evolution of more efficacious teaching methodologies, ultimately fostering a society with a higher degree of mathematical literacy. The urgency of this research is underscored by the immediate need to mitigate the widespread difficulties students encounter with integers, a fundamental concept in mathematics, and its profound implications for their future and the broader societal context.

Research Objectives/Questions

The study aimed to determine the effectiveness of MatheMagic Square Puzzle as an intervention in improving the basic operation skills on integers among Grade 7 students. Further, this study elicits pertinent information in answering the following questions:

1. What is the pretest result on the level of basic operation skills on integers of the experimental group?
2. What is the post-test result on the level of basic operation skills on integers of the experimental group?
3. Is there a significant difference between the pre-test and post-test scores of the experimental group?

Research Hypothesis

The null hypothesis, which was tested at the 0.05 level of significance, stated that there was no significant difference between the pre-test and post-test results of the experimental group. Likewise, it is stated that the intervention, MatheMagic square puzzle, cannot significantly influence the scores of the experimental group on basic operations on integers.

METHODS

Research Design

This study employed quantitative research through a one-group pretest-posttest design, a type of pre-experimental approach. It assessed changes resulting from an intervention or project by comparing values before (baseline) and after the intervention (end-line evaluation). Unlike experimental designs, pre-experimental designs lack a control group for comparison; instead, they focus on changes within a single group over time. The observed differences between baseline and end-line values are attributed to the project, suggesting its impact on the outcomes (Wamunyima & Nyirenda, 2023).

In this context, this method is necessary for conducting action research, aiming to evaluate the effectiveness of an intervention with an experimental group assigned to the study. The group underwent a pre-test and a post-test. The experimental group applied the tested strategy for teaching basic operations on integers, namely the MatheMagic square puzzle.

Sample and Population

Purposive sampling, a non-random selection technique, empowers researchers to delve into specific populations by choosing individuals, cases, or events with key characteristics aligned with the research aims. This approach, also known as judgmental sampling, leverages the researcher's expertise to identify participants who can offer the most valuable insights, unlike random selection where chance dictates participant selection (Nikolopoulou, 2023).

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In this case, the respondents for this research study are students from Grade 7, enrolled in the school year 2023-2024 at Kapalong National High School.

Table 1.
Respondents

Group	Number of Students
Experimental Group	114

Research Instrument

This study adapted one (1) questionnaire from a web source to measure the basic operations on integers. This instrument is derived from the study of Nurnberger-Haag et al. (2022). The Kuder-Richardson (KR-20) reliability statistic for the addition dimension was 0.71, 0.73 for the subtraction dimension, and 0.79 for the multiplication/division dimension. This study, however, only focused on the pre-test and post-test scores of the respondents on integers as a whole and not on the specific dimensions of integers. The test consisted of 30 integer questions, which were divided into two tests: (I) Addition and subtraction; and (II) Multiplication and division. The test on basic operations on integers consisted of 30 points with 1 point for each correct answer.

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

RESULTS

Level of Basic Operation Skills on Integers of the Experimental Group in the Pre-Test

Presented in Table 2 was the result of the pretest, indicating the performance levels of 114 students in solving basic operations on integers. The overall mean score is 10.39 or 34.65% when translated into percentage with a descriptive level of very low, indicating that the measures described in solving basic operations on integers of the students did not meet the expectation. The highest score is 21 with the frequency of 1 or 0.88% in percentage, while the lowest score is 2 with the frequency of 1 or 0.88% in percentage. Meanwhile, the mostfrequent score is 7, which has 15 frequencies, accounting for 13.16% of the population (n = 114)

Table 2.
Level of Basic Operation Skills on Integers of the Experimental Group in the Pre-Test

PRETEST SCORES	Frequency	Percentage
2	1	0.88%
3	3	2.63%
4	3	2.63%
5	8	7.02%
6	7	6.14%
7	15	13.16%
8	7	6.14%
9	9	7.89%
10	8	7.02%
11	9	7.89%
12	9	7.89%
13	3	2.63%
14	8	7.02%
15	10	8.77%
16	3	2.63%
17	5	4.39%
18	2	1.75%
19	1	0.88%
20	2	1.75%
21	1	0.88%
Total	**114**	**100.00%**
Overall		**10.39**
Description		**Low**

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Level of Basic Operation Skills on Integers of the Experimental Group in the Post-Test

Presented in Table 3 are the results of the post test, indicating the performance levels of 114 students in solving basic operations on integers. The overall mean score is 18.728 or 62.43% when translated into percentage with a descriptive level of average, indicating that the measures described in solving basic operations on integers of the students is satisfactory. The highest score is 30 with the frequency of 3 or 2.63%, while the lowest scores is 6 with the frequency of 2 or 1.75%. Meanwhile, the most frequent score is 19, which has 17 frequencies, accounting for 14.91% of the population (n=114).

Significant Difference between the Pre-Test and Pos-Test Scores of the Experimental Group

Presented in table 4 was the result of the significant difference between the pre-test and post-test scores of the experimental group, $t(113) = -19.575$, $p < .001$. Paired t-test was used in determining the answer to this question.

Since the P-value is < 0.001, which is lesser than 0.05, and the t-value is –19.75, this means that the null hypothesis was rejected. The result indicates that there is a significant difference between the pre-test and post-test results of the experimental group. In addition, this also means that the intervention, MatheMagic square puzzle, can significantly influence the scores of the experimental group on basic operations on integers.

Table 3.
Level of Basic Operation Skills on Integers of the Experimental Group in the Post-Test

POST-TEST SCORES	Frequency	Percentage
6	2	1.75%
7	1	0.88%
9	1	0.88%
10	1	0.88%
11	2	1.75%
12	5	4.39%
13	4	3.51%
14	3	2.63%
15	8	7.02%
16	6	5.26%
17	5	4.39%
18	13	11.40%
19	17	14.91%
20	6	5.26%
21	8	7.02%
22	10	8.77%
23	6	5.26%
24	6	5.26%
25	3	2.63%
26	1	0.88%
27	2	1.75%
28	1	0.88%
30	3	2.63%
Total	114	100.00%
Overall		18.728
Description		**High**

Table 4
Significant Difference between Pretest and Post-Test of the Experimental Group

Type of Test	N	df	Mean	SD	t-value	P-value	Decision $\alpha = 0.05$
Pre-Test	114	113	10.39	4.33	-19.575	**< .001**	**Significant**
Post-Test	114		18.73	4.76			

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DISCUSSION

Level of Basic Operation Skills on Integers of the Experimental Group in the Pre-Test

Before the intervention given to the students, as presented in Table 2, the result of the pretest was 10.39, classified as very low, which means the students' basic operation skills on integers did not meet the expectation. This means that the students lacked skills in solving problems on basic operations on integers. This finding is supported by Bryant et al. (2020), which also show a very low level of results in which students with mathematics difficulties significantly struggle with tasks involving integers. These challenges can manifest in various forms, such as difficulty understanding the concept of negative numbers, confusion with integer operations like addition, subtraction, multiplication, and division, and trouble applying integer rules in problem-solving contexts.

This is also in congruence with the findings of Tanghal (2020), which show an overall contribution to the very low level of performance in mathematics. Students often have difficulty solving verbal problems, partly due to their low retention of past lessons, especially on integers. These difficulties may stem from underlying issues such as poor number sense, memory deficits, or inadequate instruction methods. Consequently, students may exhibit anxiety and a lack of confidence in mathematics, leading to further disengagement and poor performance. Tailored instructional strategies, including the use of visual aids, manipulatives, and targeted practice, are crucial in helping these students improve their understanding and skills with integers.

Level of Basic Operation Skills on Integers of the Experimental Group in the Post-Test

After a month of receiving the MatheMagic Square Puzzle intervention, which focuses on game-based basic operations on integers, the post-test result was 18.728 or 64., indicating an average level of performance. This marks an almost entirely improved performance from their pre-test performance, showing that the students have now developed satisfactory skills in basic integer operations, including addition, subtraction, multiplication, and division. The results indicate that the intervention significantly enhanced their abilities in these fundamental areas. This finding of this study is supported by Chong et al. (2022), which also show average results and emphasize that non-digital card games can effectively enhance students' performance in integer operations. To deepen students' understanding of mathematical concepts, including integers, teachers should adopt student-centered learning. This approach involves engaging students with concrete materials and fostering active participation. Contemporary teaching methods advocate for student-centered strategies in mathematics, which have been linked to increased student engagement and achievement. Therefore, educators are encouraged to integrate these hands-on, student-focused methods into their mathematics instruction to improve outcomes.

Furthermore, this is also parallel to Listrianti et al. (2022), which show average level of results and claim that implementing manipulation techniques is a strategic effort to enhance students' ability to perform arithmetic operations, specifically adding integers. These techniques involve using tangible objects, such as counters, number lines, or colored chips, to represent integers visually and physically. By manipulating these materials, students can better grasp the abstract concept of adding positive and negative numbers. This hands-on approach allows learners to see the results of combining different integers, making the process more concrete and understandable. Additionally, these techniques encourage active learning and engagement, helping students build a stronger foundational understanding, which leads to improved confidence and proficiency in arithmetic operations.

Significant Difference between the Pre-test and Post-test of the Experimental Group

Based on the results, it was found that there is a significant difference between the pretest and post-test scores of the students. This indicates that the MatheMagic square puzzle intervention was effective in improving students' basic operation on integers skills. This finding supported the findings of Yagmur (2020), which emphasize that playing with Integers involves interactive activities designed to help students understand and master integer operations through engaging and hands-on methods. This approach can include games, puzzles, and manipulatives that make learning about integers fun and effective. By incorporating playful and interactive elements into mathematics instruction, teachers can create a more dynamic and stimulating learning environment. These activities not only make learning more enjoyable but also help students to better visualize and internalize mathematical concepts. Research has shown that such methods can significantly boost students' comprehension and performance in working with integers, leading to improved mathematical skills and confidence.

Moreover, numerous researchers have explored the enhancement of basic integer operation skills through interactive games such as the magic square puzzle. A study conducted by Wulandari and Damayanti (2018), which reveals that scaffolding based on the "telolet game" in teaching integers support given to help students solve problems or grasp concepts they cannot tackle on their own. Recently, technology-based scaffolding has gained prominence in education. This study introduced an educational game called "Telolet" designed to provide scaffolding for students struggling with integers. The game aims to assist learners in overcoming difficulties with integer operations through engaging and supportive gameplay.

This is also parallel with the study of Umboh (2021), which conclude that using interactive games like the Kahoot learning game application improves students' performance in integer operations while making them enthusiastic and active participants in the learning process. Additionally, it fosters students' collaborative skills by encouraging group work. For teachers, Kahoot enhances creativity and innovation in designing technology-based mathematics lessons using smartphones or Android devices.

Conclusion

Based on the findings of the study, the following conclusions were drawn:

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First, the overall mean score level of basic operation skills on integers of the experimental group in the pre-test is very low. Hence, this indicates that the result of the pre-test in solving basic operations on integers of the experimental group did not meet the expectation.

Second, the overall mean score level of basic operation skills on integers of the experimental group in the post-test is average. Thus, this indicates that the result of the post-test in solving basic operations on integers of the experimental group is satisfactory.

Lastly, the findings revealed a significant difference between the pre-test and post-test scores of the experimental group using Paired T-test. It was revealed that there is a significant difference between the pre-test and post-test results of the experimental group. Along with this, it was also revealed that the intervention, MatheMagic square puzzle, can significantly influence the scores of the experimental group on basic operations on integers.

Recommendations

Based on the study's findings, it is recommended that schools adopt the MatheMagic square puzzle as a teaching tool for Grade 7 students learning basic integer operations. This puzzle game has proven to be highly effective in enhancing students' abilities to add, subtract, multiply, and divide integers. The engaging nature of the puzzle captures students' interest and motivates them to practice these fundamental mathematical skills. By incorporating MatheMagic into classroom activities, educators can create a dynamic learning environment that promotes active participation and deeper understanding of integer operations.

Moreover, the puzzle stimulates critical thinking skills essential for mathematical problem-solving. Students are required to strategize and apply mathematical principles to solve the puzzle, thereby reinforcing their conceptual understanding of integers. This active engagement not only improves academic performance but also fosters a positive attitude towards learning mathematics. The game-based approach of MatheMagic makes the learning process enjoyable and less intimidating, encouraging even those who may struggle with traditional teaching methods to actively participate and excel.

Furthermore, we recommend conducting additional research to explore how the MatheMagic square puzzle could be utilized across different grade levels and mathematical concepts. By expanding the scope of research, we can assess its broader impact on students' mathematical development and its potential as a versatile educational tool. Understanding its effectiveness in diverse educational settings will provide valuable insights into optimizing its implementation for maximum learning outcomes. Overall, adopting the MatheMagic square puzzle in Grade 7 classrooms not only enhances integer operations skills but also cultivates critical thinking and promotes a positive learning experience in mathematics.

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