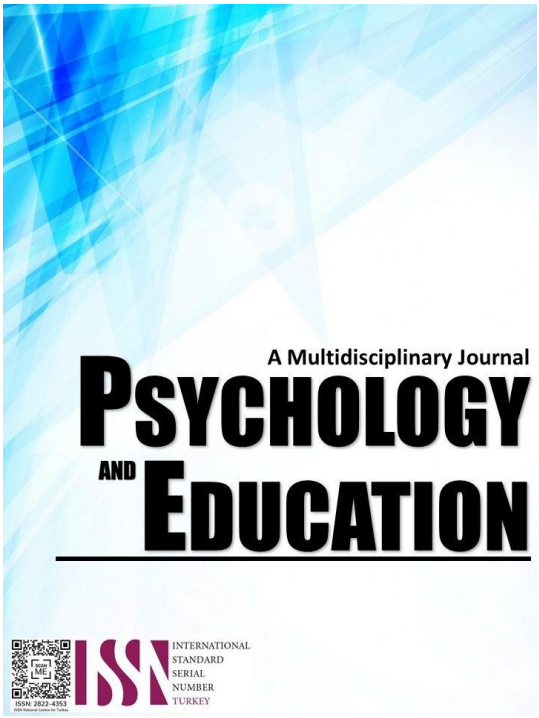
THE EFFECTIVENESS OF GAME-BASED STRATEGIES IN LEARNING MATHEMATICS



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Research Article

The Effectiveness of Game-Based Strategies in Learning Mathematics

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Abstract

This study sought to determine the effectiveness of utilizing game-based strategies in learning mathematics in the junior school specifically grade 10 students. In this study, embedded mixed methods research design was used to gather both quantitative and qualitative data from the participants in which the second served as supporting data to supplement the first. The results of the study revealed that game-based strategies provided a strong influence in maximizing learning mathematics and retention was also evident in the result of students' test performance allowing them to recall concepts learned and skillfully solve problems from the different activities they experienced with the use of the game-based strategies. Moreover, the participants shared meaningful experiences learning mathematics after the intervention. With the use of such strategies, they were able to recognize how lessons were discussed in a different manner with full of insights and realization that learning can be both engaging and rewarding. Moreover, the test performance result analyzed using mean showed an increasing average score indicating that the participants could still recall how to solve mathematical problems which took place after the intervention was utilized. Furthermore, results in the inferential statistics analyzed using Repeated Measures ANOVA also revealed that there were significant differences in the pretest, post-test, and retention test of the participants specifically majority on pretest and post-test, and pretest and retention test using post-hoc analysis. These results imply that with constant practice of utilizing teaching strategies like integrating games in class, it can improve learning outcomes, increase engagement, provide short-term retention, and promote pedagogical innovation. In education, these long-term knowledge and skills in mathematics will lead to higher test performance while aligning the 21st century skills essential in the success of teaching and learning.

Keywords: *effectiveness, game-based strategies, mathematics, test performance*

Introduction

In the 21st century, one of the most important aspects of the teaching-learning process has been recognized as the instructional approach of teachers serving as gauge for academic advancement. Students' test scores on high stakes achievement tests continue to be low even when policies like teacher professional development are put in place. Consequently, teaching methods and techniques are essential for becoming a teacher who can impart knowledge to their students using a variety of engaging approaches and strategies. Teachers must employ the most effective method for imparting knowledge.

Mathematics is an essential subject taught in elementary and secondary education that gives learners the basic information and abilities they need to manage their life (Ariyanti & Santoso, 2020). According to Kamarudin et al. (2019), the level of student interest in teaching and learning is low when the traditional approach is employed.

According 2022 report of PISA, Over the most recent period (2018 to 2022), the gap between the highest-scoring students (10% with the highest scores) and the weakest students (10% with the lowest scores) narrowed in mathematics, while it did not change significantly in reading and science. In mathematics, low-achievers became stronger, while performance did not change significantly amongst high-achievers.

Math education has relied on traditional teaching methods like lectures and textbooks. Nevertheless, research has shown that these strategies are ineffective in boosting academic achievement and inspiring students (Chen et al., 2020). Teachers have turned to innovative teaching techniques like game-based learning to boost learners' academic performance and enthusiasm for mathematics.

One of the main educational trends of the twenty-first century is game-based strategies, also known as game-based learning (Ahmad & Iksan, 2021). In recent years, there has been a growing body of scholarly research on this topic (Zou, 2020). GBL is a method of teaching mathematics that enhances learning efficiency through student-centered learning activities and strikes a balance between traditional classroom instruction and educational games (Lasut & Bawengan, 2020). Students will indirectly pay attention to the teacher's lessons because it is one of the more inventive and engaging teaching strategies. The reason for this is that students are naturally inclined to play games. According to Liu et al. (2021), educational games can also foster a love of learning, a sense of comfort in facing a range of obstacles, and the ability to overcome these obstacles with patience, focus, and self-assurance—all of which are critical for higher education and the development of lifelong learners.

According to Vanbecelaere et al. (2020), the majority of existing research on game-based learning examines the games' effectiveness just after the learning process, from a limited point of view. As of right now, there is insufficient data to say if game-based learning helps learners retain what they have learned. Game-based learning strategies can help students retain important concepts is still an important question.

In Kabankalan Catholic College, one of the challenges encountered by mathematics teachers is strategizing teaching ways to make teaching and learning efficient, engaging, and long lasting. Based from the record of grade 10 mathematics teachers, those who have mastery of mathematics specifically topics on combinatorics ranges only from 20% to 30%. With the problems mentioned, this led me to study the effectiveness of game-based strategies in learning mathematics by addressing this gap by employing an embedded mixed methods research design to comprehensively explore the impact of game-based strategies on mathematics learning among grade 10 students by synthesizing quantitative data on test performance with qualitative insights into students' experiences and perceptions.

Research Questions

This study aimed to determine the effectiveness of game-based strategies in learning mathematics of the grade 10 students in the junior high school. Specifically, it sought to answer the following questions:

1. What is the test performance of the participants in combinatorics on the pretest as a whole and in terms of the following:
    1.1. Permutation
    1.2. Combination
2. What is the test performance of the participants in combinatorics on the post-test as a whole and in terms of the following:
    2.1. Permutation
    2.2. Combination
3. What is the test performance of the participants in combinatorics on the retention test as a whole and in terms of the following:
    3.1. Permutation
    3.2. Combination
4. Is there a significant difference on the test performance of the participants in combinatorics on the pretest, post-test, and retention test?
5. What are the experiences of the key informants in their mathematics class?

Methodology

This study used an embedded mixed-methods research design to determine the test performance and experiences of students before and after the intervention. Embedded design is a mixed methods research approach where one form of data is embedded within another. This method involves gathering quantitative and qualitative data simultaneously, with one type serving as the primary method and the other as the secondary method (Hassan, 2023). In this method, I gathered quantitative data: pretest, posttest, and retention test, which were supported by the results from the interview that were gathered after the retention test.

For the quantitative component of the study, one section was purposively chosen as a participating section having 50 participants officially enrolled in Kabankalan Catholic College- High School Department for school year 2024-2025. The section that was chosen experienced traditional way of learning mathematics and has not yet been exposed to game-based strategies in the lessons on combinatorics specifically on permutation and combination. The qualitative component had the eight (8) participants with the highest and lowest scores before and after the intervention. Purposive sampling is a research method where individuals or groups are chosen based on specific criteria relevant to the research question or objective, without using random selection (Hassan, 2023).

The test questionnaire in this study was divided into three (3) parts. The first part is the consent form and the second part is a self-made research questionnaire consisting of forty questions (40) questions on combinatorics of which twenty (20) for permutation and twenty (20) for combination. Sixty percent of which is easy, thirty percent (30%) is average, and ten percent (10%) is difficult. The last part is the three (3) open-ended questions for the participants to share their experiences on their challenges, ways to cope up, and insights to the new way of learning mathematics utilizing game-based strategies.

The validity score was 0.832 which means that the research instrument was indeed valid. The instrument used in gathering the data undergone a validity process by the five (5) experts in the field of Mathematics. The Content Validity Form was used to measure the accuracy of the instrument. Specifically, Content Validity Ratio (CVR) was used to measure the accuracy of the instrument. The content validity ratio (CVR), which is suggested by Lawshe (1975), involves asking experts to determine whether the knowledge or skill that each item on the test assesses is “essential,” “useful, but not necessary,” or “not necessary” (Frost, 2023). Reliability was used to measure the quality and consistency of the research and to determine whether to trust the results of the study (Carroll, 2022). The result of the reliability test was 0.879 using the Kuder-Richardson Formula 20 (KR20) administered to forty (40) students. This test of internal consistency measures the test with dichotomous choices (answer options that are either right or wrong), which range from 0 to 1, with higher values indicating higher reliability (Zach, 2022).

In gathering data, the following procedures were observed: First, letters were sent to the high school principal requesting permits for various tests and an interview. Another letter was addressed to the registrar to obtain the list of students. After securing approvals, the research instrument was developed and subjected to content validity and pilot testing. Additionally, a letter of validation request was forwarded to the three (3) experts in the field of Mathematics. Moreover, once permissions are secured, a pilot test was conducted on forty (40) students from the other sections who are not part of the study to test and refine the procedures of the study. Lastly, after the retention test, letters were sent to the interviewees and the interview was conducted with the eight (8) participants with the highest and

lowest scores before and after the intervention. Results were analyzed and interpreted after the final administration of the instrument.

Based on the specific objectives and hypotheses established earlier in this study, the data were analyzed using appropriate statistical tools. On problems 1, 2, and 3, to determine the test performance of the participants on the pretest, post-test, and retention test, mean was used. The mean is known as the average. The total sum values in a sample are divided by the number of values in the set (Hurley et al. 2021). On problem 4, to test the significant difference on the test performance of the participants in mathematics on the pretest, post-test, and retention test, repeated ANOVA was used. The one-way repeated measures ANOVA is a statistical test that is parametric in nature and is utilized to compare three or more groups within an experiment that includes the same subjects or cases (Jasrai, 2021). On problem 5, to gather the experiences or insights learned by the participants before and after the intervention, narrative analysis was used. Narrative analysis is a qualitative method that focuses on interpreting human experiences and motivations. It involves closely examining the stories, or narratives, that people tell within a specific context (Jansen, 2023).

In this study, I used the interpretation of test performance with the following percentage range and descriptions: 90% - 100% (Excellent: Outstanding performance, demonstrating mastery of concepts and skills); 80% - 89% (Very Good: Strong performance, with a thorough understanding of concepts and skills); 70% - 79% (Good: Solid performance, meeting expectations with a good grasp of concepts and skills); 60% - 69% (Satisfactory: Adequate performance, demonstrating basic understanding but with room for improvement); 50% - 59% (Needs Improvement: Below-average performance, indicating areas requiring attention and improvement); 40% - 49% (Poor: Substandard performance, with significant gaps in understanding and skills); 0% - 39% (Very Poor: Failing performance, indicating fundamental misunderstanding and lack of proficiency).

Results and Discussion

Table 1. *Test performance of the participants in combinatorics on the pretest as a whole and in terms of the following areas*

Areas	*Mean % and Interpretation*			
	Easy	*Average*	*Difficult*	*Total*
Permutation	31.00^{VP}	30.67^{VP}	19.00^{VP}	29.70^{VP}
Combination	23.67^{VP}	21.67^{VP}	14.00^{VP}	22.10^{VP}
As a whole	27.34^{VP}	26.17^{VP}	16.50^{VP}	25.90^{VP}

E=Excellent; VG=Very Good; G=Good; S=Satisfactory; NI=Needs Improvement; P=Poor; VG=Very Poor

Table 1 shows the test performance of the participants in combinatorics on the pretest. Based from the result, it reveals that mean percentage for both topics on permutation (M=29.70) and combination (M=22.10) and taken a whole (M=25.90) are all interpreted as very poor. Furthermore, as the level of difficulty increased, it shows that the test performance of the participants kept on decreasing. This result implies that in the traditional way of learning mathematics based from the participants' previous experience, students are not able to grasp the content standards set due to a very poor result from the pretest. Also, students struggle answering difficult problems especially word problems that need advanced comprehension and understanding of the topics.

According to key informant 2, "As someone who does not like mathematics, one of the struggles that I have is my short-term memory loss. Whenever I solve problems with the guidance of the teacher, I can easily answer the question. But when I answer it on my own, I feel like learned nothing; my mind does not work anymore. Informant 4 also added, "When a teacher discusses anything that is related to mathematics, I personally find myself getting confused at times because I find the lessons complex and tricky, causing me to forget things because I have trouble remembering everything all at once. I sometimes feel overwhelmed and frustrated when keeping up with the lessons, making it harder for me to remember and apply what learned.

Although other students might find this method helpful, as someone who is practically not good in mathematics, I find it very challenging. Likewise, informant 8 added, "Learning math with just lecture and activity is hard to understand without an example. When using these math ideas in our own work, it is very challenging because I have not seen how it is supposed to work in practice especially in a very engaging way. Another point when using the lecture and activity format, it is not that engaging, sitting through lectures and then going to activities without much interaction or excitement makes it hard to stay focused and interested in the subject."

According to Bernardo et al. (2022), the majority of Filipino high school students are not studying the required amount of mathematics, and the problem appears to be worse for students in Philippine high schools. The Philippines has been doing badly in mathematics in the international evaluations, thus the results are somewhat expected.

Table 2. *Test performance of the participants in combinatorics on the post-test as a whole and in terms of the following areas*

Areas	*Mean % and Interpretation*			
	Easy	*Average*	*Difficult*	*Total*
Permutation	42.50^{P}	54.00^{NI}	32.00^{VP}	44.90^{P}
Combination	38.67^{VP}	51.67^{NI}	32.00^{VP}	41.90^{P}
As a whole	40.59^{P}	52.84^{NI}	32.00^{VP}	43.40^{P}

E=Excellent; VG=Very Good; G=Good; S=Satisfactory; NI=Needs Improvement; P=Poor; VG=Very Poor

Table 2 shows the test performance of the participants in combinatorics on the post-test. Based from the result, it reveals that mean percentage for both topics on permutation (M=44.90) and combination (M=41.90) and taken a whole (M=43.40) are all interpreted as poor after utilizing the game-based strategies in learning mathematics. Comparing results from the pretest and post-test, the descriptive result from the table shows an increase of mean percentage compared to the previous one. Furthermore, average questions yielded highest results compared to the other levels. Majority on the easy questions resulted to "poor", "needs improvement" on the average questions, "very poor" on the difficult questions, and "poor" in total. This result implies that there is an increase of mean percentage score after utilizing the intervention. An increase of result shows on how effective game-based strategies when used by teachers in maximizing the potential of learners in solving math problems. Furthermore, game-based strategies are engaging activities that elicit responses from the participants without compromising the content and performance standards set beforehand.

According to informant 2, "With the help of game-based strategies, I feel like my mind works more effectively due to the adrenaline rush. It makes me quicker to answer questions, and I feel like all my brain cells are working together. Informants 3 and 4 having the same experience also expressed that, "When our teacher uses game-based strategies, I find math easier to comprehend. With the help of teammates in reviewing the lessons and the cheers during the game, I get to enjoy math more. I do not feel pressured whenever the teacher uses game-based strategies. Most importantly, math becomes more fun and enjoyable because of these strategies. Also, it helps me to encourage myself that I should try harder despite the fact that I am not that good when it comes to mathematics. It also helps in making memorable experiences because it causes you to be more interactive with everyone in the room."

Table 3. *Test performance of the participants in combinatorics on the retention test as a whole and in terms of the following areas*

Areas	*Mean % and Interpretation*			
	Easy	*Average*	*Difficult*	*Total*
Permutation	45.17P	48.33P	28.00VP	44.40P
Combination	46.50P	45.00P	28.00VP	44.20P
As a whole	45.84P	46.67P	28.00VP	44.30P

E=Excellent; VG=Very Good; G=Good; S=Satisfactory; NI=Needs Improvement; P=Poor; VG=Very Poor

Table 3 shows the test performance of the participants in combinatorics on the retention test. Based from the result, it reveals that mean percentage for both topics on permutation (M=44.40) and combination (M=44.20) and taken a whole (M=44.30) are all interpreted as poor. This result shows that 2 weeks after the post-test was administered, remembering the concepts learned and skills developed are still evident though there are minor differences on the test performance.

Comparing now the result of the retention test to the previous tests administered, the descriptive result shows a little difference between post-test and retention test, and a larger percentage almost double between pretest and retention test. The improvement of test performance though labeled from "very poor" to "poor" is still an indicator that there are changes that happened after the intervention was used. Furthermore, both easy and average questions yielded almost the same test results "poor" compared to the difficult questions interpreted as "very poor". This result implies that in terms of descriptive statistics, the test results increased after the game-based strategies as an intervention was utilized in class. Also, maximizing the use of such strategy enabled learned to performance better though labeled "poor" can still remember content learned and skills are still evident.

According to informants 1, "After few weeks, I can still remember the concepts or ways to solve problems. It developed my problem solving-skills after using game-based strategies and enabled me my brain to solve challenging math problems. Problems are still difficult but now I can cope up compared before." Informant 3 added, "After few weeks of engaging in game-based strategies, I can say that I can no longer remember most of the concepts or ways to solve problems but I can remember some of them. I have a short-term memory loss, so most of the time, I have a hard time recalling things and that includes the concepts and ways in problem-solving. However, if someone teaches me or discusses the lessons with me again using other ways, I will be able to remember them." Informant 8 also added, "Usually, I forget majority of the concepts learned in class and resort to skimming the material, but with game-based strategies the topic is retained in my mind because the game is memorable than just having lectures. Game-based strategies encourages me to do self-study and keeps the topic refreshed in my mind."

Table 4.1. *Difference Analysis on the test performance of the participants in combinatorics specifically in permutation on the pretest, post-test, and retention test*

Levels	*Wilk's λ*	*F*	*p*	*Conclusion*
Easy	0.661	12.294	0.000	Highly Sig.
Average	0.464	27.731	0.000	Highly Sig.
Difficult	0.853	4.139	0.022	Sig.
Total	0.415	33.896	0.000	Highly Sig.

Not Sig. if p-value is greater than 0.05; sig. and highly sig. if p-value is less than 0.05 and 0.01, respectively

The table presents the difference analysis on the test performance of the participants in combinatorics specifically in permutation on the pretest, post-test, and retention test. Based from the result, it shows that there are highly significant differences on the test performance on the easy (λ=0.661; F=12.294; p=0.000), average (λ=0.464; F=27.731 p=0.000), and in total (λ=0.415; F=33.896;

p=0.000), and significant on the difficulty level (λ=0.853; F=4.139; p=0.022). This implies that the test performance of the participants in combinatorics specifically in permutation vary on the pretest, post-test, and retention test on different levels. Test performance in mathematics is significantly below the expected standards, demonstrating lack of understanding and proficiency in the lessons discussed. Furthermore, this is evident on the result of Post-hoc Analysis where there are specific significant differences exist among levels. On the easy level, pretest and post-test (p=0.001), pretest and retention test (p=0.000) have significant differences. On the average level, pretest and post-test (p=0.000), pretest and retention test (p=0.000) also have significant differences. On the difficult level, only pretest and post-test (p=0.033) have significant difference. Overall, pretest and post-test (p=0.000), pretest and retention test (p=0.000) are significantly different. These pairwise comparisons imply that the intervention was effective in increasing the test performance of students specifically after the intervention was utilized. As the level of difficulty increases, retention of the participants tend to slow down but not totally compromising their mastery.

The significant differences on the test performance of the participants in combinatorics specifically in permutation on the pretest, post-test, and retention test are supported by the testimonies of the selected participants. According to informant 7, "Games can help us to build our confidence in mathematics and it helps us spend more time on concepts that we can find challenging and I can learn on our own." Informant 2 added, "After few weeks, though I think I read some problems regarding the past lessons, I feel I can somehow remember the lesson but find it challenging on how to solve the problem except for the lessons that I find easier to solve. As someone who easily forgets details, it is very hard for me to retain all the lessons that I have learned."

Additionally, in the 2018 International Student Assessment program, Filipino students performed among the lowest performing student groups across all participating nations (PISA). Less than 20% of students in mathematics met the minimal competency requirement (Level 2), while over 50% shown extremely low ability (below Level 1). These Filipino students, who scored below the lowest level of proficiency on the PISA, have obviously left behind from other students in other countries when it comes to mathematics education; over half of this age group of Filipino students are not as proficient in mathematics from other countries. Students in public and private schools performed poorly in mathematics to varying degrees; the means for each group were 343 and 395, respectively (Department of Education, 2019).

Table 4.2. *Difference Analysis on the test performance of the participants in combinatorics specifically in combination on the pretest, post-test, and retention test*

Levels	*Wilk's λ*	*F*	*p*	*Conclusion*
Easy	0.395	36.799	0.000	Highly Sig.
Average	0.366	41.485	0.000	Highly Sig.
Difficult	0.776	6.909	0.002	Highly Sig.
Total	0.206	92.259	0.000	Highly Sig.

Not Sig. if p-value is greater than 0.05; sig. and highly sig. if p-value is less than 0.05 and 0.01, respectively

The table shows the difference analysis on the test performance of the participants in combinatorics specifically in combination on the pretest, post-test, and retention test. Based from the result, it presents that there are highly significant differences on the test performance on the easy (λ=0.395; F=36.799; p=0.000), average (λ=0.366; F=41.485; p=0.000), difficult (λ=0.776; F=6.909; p=0.002), and in total (λ=0.206; F=92.259; p=0.000). This result implies that the test performance of the participants in combinatorics specifically in combination vary on the pretest, post-test, and retention test on different levels. The test performance in mathematics still shows low mastery in answering problems in combination though improvement was evident after the intervention was made used in the study. Furthermore, Post-hoc Analysis showed specific significant differences exist among levels. On the easy level, pretest and post-test (p=0.000), pretest and retention test (p=0.000), post-test and retention test (p=0.000) have significant differences. On the average and difficult levels, and overall, pretest and post-test (p=0.000), pretest and retention test (p=0.000) also have significant differences. The pairwise comparisons imply that the intervention was indeed effective in increasing the test performance of students. The participants find it easy to recall concepts in combination than in permutation because in this topic there are minor rules to remember and less complex than permutation.

The significant differences on the test performance of the participants in combinatorics specifically in combination on the pretest, post-test, and retention test are supported by the testimonies of the selected participants. According to informant 8, "When game-based strategies are being used, it helps the topic be more meaningful and enjoying especially in combinations where concepts are easily understood. The interactive and hands-on activities are very engaging. Instead of just listening to the lectures in class, I am actively engaged and having fun. Game-based strategies made mathematics feel less boring and more like a challenge I want to tackle. Additionally, informant 4 said, "Interactive nature of the game can cause a long-lasting memory, and it can stimulate my mind, resulting in a much more reinforced understanding. Whenever I engage myself in these game-based strategies, it is much easier for me to retain or recall the information."

Interviews from different key informants which are essential findings in this study are supported by some related studies. According to Lampropoulos et al. (2022), students participate more actively in the learning activities, show greater engagement, enthusiasm, and improve their critical thinking and problem-solving skills. Game-based strategies encourages socialization, which in turn fosters positive behaviors, productivity, satisfaction, teamwork, and communication. It can also result in delightful social interactions amongst

groups. This kind of method has components that function as motivators have a favorable impact on performance generally, even in areas unrelated to education, and help develop essential career competences while simultaneously serving as social comparison tools.

Table 4.3. *Difference Analysis on the test performance of the participants in combinatorics as a whole on the pretest, post-test, and retention test*

Levels	*Wilk's λ*	*F*	*p*	*Conclusion*
Easy	0.364	42.000	0.000	Highly Sig.
Average	0.304	55.074	0.000	Highly Sig.
Difficult	0.727	8.991	0.000	Highly Sig.
Total	0.182	107.858	0.000	Highly Sig.

Not Sig. if p-value is greater than 0.05; sig. and highly sig. if p-value is less than 0.05 and 0.01, respectively

The table presents the difference analysis on the test performance of the participants in combinatorics as a whole on the pretest, post-test, and retention test. The result shows all have highly significant differences on the test performance on the easy (λ=0.364; F=42.000; p=0.000), average (λ=0.304; F=55.074; p=0.000), difficult (λ=0.727; F=8.991; p=0.000), and in total (λ=0.182; F=107.858; p=0.000). This result implies that the test performance of the participants in combinatorics (permutation and combination are combined), the pretest, post-test, and retention test on different levels vary significantly. Considering the overall result, there is a statistical proof that with the integration of game-based strategies, test performance will increase but not totally reaching passing rate standards. Furthermore, Post-hoc Analysis showed all significant differences exist among levels. On the easy level, pretest and post-test (p=0.000), pretest and retention test (p=0.000), post-test and retention test (p=0.027) have significant differences. On the average and overall, only pretest and post-test (p=0.000), pretest and retention test (p=0.000) have significant differences. In the difficult level, pretest and post-test (p=0.000), pretest and retention test (p=0.004) also have significant differences.

The pairwise comparisons show the improvement of students' test performance because of the intervention. They find it easier to remember ideas when they are presented in an engaging manner utilizing games as a strategy involved in learning. These quantitative result are further supported by interview on selected participants. According to informant 5, "We play variety of games, but the one that sticks in my memory the most is the flip the bottle game, which tests our ability to focus on scoring as well as winning. Therefore, the harder the task, the more motivated we are to succeed. especially in the case of cooperative games. Group math games force us to collaborate, share ideas, and justify our mathematical reasoning, which promotes teamwork. We find that these teamwork and communication skills are really helpful while working with challenging mathematical problems, which often require the ability to clearly express our views. Informant 7 also added, "When it comes to math, I cannot immediately give feedback about what I have learned because I cannot understand it easily even though it is easy to say but because of games strategies somehow I still remember something but not all."

The result of the interview is further supported by related studies on test performance in mathematics increased after maximizing the use of game-based strategies. According to Sapin (2022), using game-based learning in teaching influences the development of students' positive attitudes toward mathematics as the most challenging subject and boosts their motivation, accelerated acquisition, and long-term memory. Furthermore, this study supported the notion that problem-solving in mathematics classes can benefit from game-based learning. This study found evidence that using smartphones or video games helps and improves mathematics learning outcomes.

Conclusions

In conclusion, this study sought to understand the effectiveness of game-based strategies in learning mathematics specifically lessons on combinatorics during the school year 2024-2025. It examined the students' test performance on the pretest, post-test, and retention test considering different levels on easy, average, and difficult test items. The findings revealed significant results on different areas of combinatorics such as premutation and combinations and the experiences of the students before and after the intervention.

Moreover, this study analyzed the test performance following research processes, identifying research gaps, choice of research design, data gathering procedures, data analyses and interpretation. This study made use of game-based strategies as an intervention to dwell on the significant findings based from the result of pretest, post-test, and retention test. Also, insights coming from the participants through the qualitative analysis were collected and analyzed using narrative analysis to support the result on the quantitative analysis.

With a clear result after the intervention both on the post-test and retention test, a consistent use of games into instructional procedures in the classroom is a very important as an educational approach with numerous advantages. Teachers can use games to enhance learning outcomes in a variety of subjects and grade levels with constant practice. The utilization of games fosters deeper understanding and retention of educational content. By contextualizing concepts within interactive and immersive gameplay experiences, students are more likely to grasp complex ideas and retain information over the long term. The inherent challenge and reward structure of games motivate learners to actively engage with the material, reinforcing their comprehension through repeated practice and application. Games significantly enhance student engagement in the learning process. Unlike traditional instructional methods, games capture students' attention by tapping into their innate curiosity and desire for exploration. By providing a dynamic and interactive learning environment, games promote active participation and intrinsic motivation, resulting in higher levels of student involvement and enthusiasm for learning.

Furthermore, the short-term retention facilitated by game-based learning serves as a springboard for long-term memory formation. By incorporating repetition and reinforcement mechanisms into gameplay mechanics, educators can reinforce key concepts and skills over time, ensuring durable learning outcomes that extend beyond the immediate classroom setting. The consistent integration of games into teaching practices encourages pedagogical innovation and experimentation. By embracing game-based approaches, educators are prompted to explore new instructional methods and technologies, adapt teaching strategies to meet diverse learning needs, and cultivate a culture of creativity and collaboration within the classroom.

In summary, the constant practice of utilizing teaching strategies that integrate games not only improves learning outcomes and increases engagement but also facilitates short-term retention and promotes pedagogical innovation. By harnessing the educational potential of games, educators can create dynamic and enriching learning experiences that empower students to succeed in the ever-evolving world of mathematics.

Based on the results of this study, it is suggested that a program for improving retention in mathematics must be carefully planned and executed. This program will address the gaps that have been found and be able to provide better solutions to the existing problem. In doing so, it will work to raise the caliber and influence of research projects in the field of mathematics and education, which will ultimately benefit both educators and students. This will include the following:

Gamify Assessment. Consider adopting game-based assessments like simulations, scenarios, or interactive projects in place of conventional examinations or quizzes. This makes it possible for students to present their understanding in a style that is livelier and captivating.

Incorporate real-world applications. Making connections between mathematical ideas and practical situations can improve students' comprehension and motivation. Teachers can boost student retention and engagement by incorporating real-world examples and applications into the curriculum. This will enable students to recognize the relevance of math in their daily life.

Using technology effectively. Students' involvement can be improved and more practice and exploration opportunities can be given by incorporating technological tools like interactive simulations, online platforms, and educational apps. In order to meet the needs of each unique learner, technology can also provide tailored feedback and flexible learning opportunities.

Mentorship Programs. Assign newly hired math teachers to seasoned mentors who can offer advice and encouragement on their methods of instruction. The effectiveness of new teachers in the classroom can be increased via mentoring programs, which can assist them in overcoming obstacles and gaining confidence in teaching.

Specialized Training Workshops. Provide specialized training in the form of seminars or workshops on how to teach mathematics in an efficient way. These seminars might address issues including common misconceptions, problem-solving techniques, utilizing technology in the math classroom, and differentiated instruction.

Action Research Projects. Motivate math teachers to work on action research projects that will enhance their methods of instruction and the learning outcomes of their students. Action research offers teachers a methodical framework for examining certain teaching techniques, interventions, or curriculum improvements.

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