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Mathematical Achievements with or without Games in Hinangutdan Public Secondary High School, Samar, Philippines

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Abstract: Mathematical Achievements with or without Game in Hinangutdan Public Secondary High School, Samar, Philippines. **Objectives:** This study determined the effects of games on the mathematics achievement of Grade VII students of Hinangutdan National High School. **Methods:** It utilized quasi-experimental design to establish the effects of teaching with mathematical games (MathDoku, DaMath, Number puzzle, magic squares, and outdoor games races) and without mathematical games on mathematics achievement. There were twenty-eight participants and randomly assigned to the experimental group and the control group. **Findings:** Results showed a significant higher mean posttest score than mean pretest scores for both groups, suggesting that the two methods are effective. It indicated that teaching with and without mathematical games are equally effective in improving mathematics achievement. **Conclusion:** It has been determined that using mathematical games in the classroom is effective in raising students' math achievement, particularly in terms of their understanding of basic operations on integers and rational numbers.

Keywords: mathematical games, students' achievement, experimental design.

Abstrak: Prestasi Matematika dengan atau tanpa Game di SMA Negeri Hinangutdan, Samar, Filipina. ***Tujuan:*** *Penelitian ini untuk mengetahui pengaruh permainan terhadap prestasi belajar matematika siswa kelas VII SMA Negeri Hinangutdan. Metode: Ini menggunakan desain kuasi-eksperimental untuk menetapkan efek pengajaran dengan permainan matematika (MathDoku, DaMath, Puzzle angka, kotak ajaib, dan permainan luar ruang balapan) dan tanpa permainan matematika terhadap prestasi belajar matematika. Ada dua puluh delapan peserta dan ditugaskan secara acak ke kelompok eksperimen dan kelompok kontrol. Temuan: Hasil menunjukkan nilai rata-rata posttest yang lebih tinggi secara signifikan daripada nilai rata-rata pretest untuk kedua kelompok, menunjukkan bahwa kedua metode tersebut efektif. Hal ini menunjukkan bahwa pengajaran dengan dan tanpa permainan matematika sama efektifnya dalam meningkatkan prestasi belajar matematika. Kesimpulan: Telah ditentukan bahwa penggunaan permainan matematika di kelas efektif dalam meningkatkan prestasi matematika siswa, khususnya dalam hal pemahaman mereka tentang operasi dasar bilangan bulat dan bilangan rasional.*

Kata kunci: *permainan matematika, prestasi belajar siswa, desain eksperimental.*

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INTRODUCTION

In teaching Mathematics, teachers need to present lessons in interesting ways such as the incorporation of mathematical games in instruction. A mathematical game is one of the teaching strategies that facilitate deeper understanding, stimulate student interest and involvement, develop creativity, and enhance problem-solving skills (Cabuquin, 2022). However, the effectiveness of mathematical games in teaching depends on the active involvement of learners (Nekang, 2018; Cahill, 2021).

Games are frequently thought of as an excellent technique to get students interested in math by fostering a good learning atmosphere, increasing student motivation, and sparking mathematical discussions (Bragg, 2012). Games promotes strategic thinking and problem-solving and develops fluency (Rondina & Roble, 2019; Vankúš, 2021; Deng et. al., 2020). According to Bragg (2012), while playing games, students can explore multiple approaches to problem-solving and enhance their understanding of numbers. This fosters strategic mathematical thinking. He also made the point that playing games gives students the chance to explore basic mathematical ideas that aid in learning.

In the Philippines, just as in many other countries, the main goal of the K to 12 Basic Education Program is to develop the critical thinking and problem-solving skills of learners. The development of numerical and mathematical abilities, such as estimating, computing, and solving; picturing and modeling; representing and communicating; conjecturing, reasoning, proving, and deciding; and applying and connecting, go hand in hand with learning these skills. Students must acquire these foundational skills in a variety of subject areas, including measurement, geometry, algebra, patterns, and statistics and probability (Rondina & Roble, 2019; Taklay, 2013; Tocak et. al., 2019).

However, several international assessments have shown that Filipino learners have low Mathematics achievement. For instance, the most recent Trends in International Mathematics and Science Study conducted in 2019 showed that the Philippines got the lowest score for fourth grade Mathematics among fifty-eight participating countries. Meanwhile, the 2016 – 2017 Global Competitiveness Report indicated that the Philippines ranked 79th out of the 138 participating countries in terms of the quality of Mathematics education (Schwab, 2016).

Indeed, providing quality education to learners is a challenging task. It demands a great deal of effort, hard work, commitment, and passion from the teachers. In teaching Mathematics, just as in many other subjects, teachers are expected to employ instructional strategies that stimulate student interest, motivation, and engagement for the students to learn the lessons more effectively (Cabuquin, 2022; Ke, 2016; Karamert & Kuyumcu Vardar, 2021). Hanus and Fox (2015) and Bragg (2012) mentioned that effective learning is supported by learning experiences that ensure understanding, while effective teaching involves shaping a rich learning environment as well as utilizing instructional materials and device that attract the attention of the learners, stimulate their thinking, and facilitate understanding.

The study of Rondina and Roble (2019) employed a quasi-experimental research design to examine the effect of game-based activities on the achievement of students in Algebra. The games were "A Line to Win" and "Sliding a Picture. The former was intended to develop the students' computational skills related to the concept of quadratic functions, while the latter was intended to develop students' skills in graphing quadratic functions. The findings demonstrated that students exposed to the game-based activities had significantly higher mean posttest scores than students exposed to conventional method of

teaching that included activities such as board and seat works as well as regular assignments and quizzes.

Meanwhile, the study of Lim (2021) showed that integrating games in Mathematics teaching does not always result in significant gains in students' Mathematics scores. The study utilized the one group pretest – posttest experimental design to determine the effect of mathematical games on students' problem-solving skills. Results showed no significant difference between the mean pretest score and the mean posttest score, suggesting that the use of games in teaching Mathematics may not always be effective.

Game-based learning in Mathematics classes has gained increasing popularity over the years, and various types of games have been identified to benefit the students, including flash card-type games, simulation games, interactives, quiz games, puzzles, strategy games, and reality testing games, among others (Dimitra et al., 2020; Chen et. al., 2020; Cozar-Gutierez & Saez-Lopez, 2016). Majority of the past studies on mathematical games indicated that incorporating games in Mathematics teaching significantly improves students' Mathematics achievement and that this strategy is more effective than the traditional teaching approach (Byun & Joung, 2018; D'Angelo, Rutstein & Harris, 2016; Rondina & Roble, 2019; Taclay, 2013). However, there is also evidence, although insignificant in amount, showing that mathematical games do not always result in substantial achievement gains (Lim, 2021; De-Marcos et. al., 2014), showing minor inconsistency in the results as mentioned.

In view of the viability of mathematical games as part of Mathematics teaching, the researchers were motivated to conduct this study to determine the effectiveness of selected mathematical games including DaMath, magic square, Mathdoku, outdoor amazing race, and puzzle in improving the achievement of students in Mathematics. Although the literature is replete with studies focusing on game-based learning, games in such studies do not necessarily apply to different student populations owing to differences in population characteristics as well as differences in mathematical concepts featured in such games. Thus, this study would contribute to the existing list of effective mathematical games featured in the literature.

As mentioned, the main objective of this study was to determine the effect of Mathematical Games on students' performance in Grade VII. Specifically, this study examined the (1) Mathematics achievement of the students taught with and without mathematical games; (2) difference between the pretest scores of the students taught with and without mathematical games; (3) difference between the pretest and posttest scores of the students taught with mathematical games (4) difference between the pretest and posttest scores of the students taught without mathematical games; and examined the (5) difference between the posttest scores of the students taught with and without mathematical games.

METHODS

Participants

The participants of the study were twenty-eight (28) grade seven students who were enrolled during the school year 2021-2022 in Hinangutdan National High School, Sta. Rita, Samar, Philippines. The researchers also utilized the students' grades in Mathematics VI as criterion, and the matched pairs technique was used to divide the students into the experimental and the control group. In a matched pair, the students have approximately the same grades to ensure group equivalency. Moreover, each student in the pair is randomly assigned to the experimental and the control group, respectively.

Research Design and Procedures

This study utilized quasi-experimental design to determine the effect of mathematical games on the achievement of students in Mathematics. In this design, participants are randomly assigned to an experimental group and a control group. Both groups are assessed before (pretest) and after (posttest) a treatment is introduced to the experimental group (Edmonds & Kennedy, 2016). Prior to the conduct of the experiment, permission was sought from the Office of Sta. Rita I District, the Local IATF of Barangay Hinangutdan, and the parents of the participants. A signed parents' consent of the participants was also sought to ensure their voluntary participation in the study. It was likewise ensured that the participants were not harmed in any way during the conduct of the study. Safety prevention protocols against COVID-19 were observed. Participants wore face masks and shields during their participation in class discussions and washed their hands before and after classes.

Moreover, to ensure group equivalency, the matched pairs technique was used, with students' general percentage average as the criterion for pairing. Then, students in each pair were randomly allocated to the experimental group and the control group using the fishbowl method. The experimental and the control group included fourteen students each after the random assignment. Then, a 50-item pretest measuring Mathematics achievement was administered to both the experimental and the control group. The pretest measured prior knowledge on fundamental operations on integers and rational numbers – addition, subtraction, multiplication, and division. Pretest scores were compared to check homogeneity between the two groups in terms of prior knowledge. Mathematical games comprised the treatment for the experimental group. The games were MathDoku, DaMath, number puzzle, magic square, and outdoor amazing race. The experimental group was exposed to a series of lessons on fundamental operations on integers and rational numbers with the use of mathematical games as a teaching strategy. MathDoku was used in the lesson on addition of integers. DaMath was used in the lesson on subtraction and division of integers and multiplication and division of rational numbers. For lessons on multiplication of integers and addition and subtraction of rational numbers, the games used were number puzzle, magic square, and outdoor amazing race, respectively. On the other hand, the control group was also given a series of lessons on the same topic but without the mathematical games. After the experimental group had been exposed to instruction with mathematical games and the control group to instruction without mathematical games, both groups were given a posttest utilizing a 50-item Mathematics achievement test parallel to the one used in the pretest.

Instrument

A 50-item Mathematics achievement test was used to determine the pretest and posttest scores of the experimental group and the control group. The test was multiple-choice type and covered fundamental operations on integers and rational numbers, namely addition, subtraction, multiplication, and division. The level of difficulty of the questions was based on the six levels of cognitive learning from the revised version of Bloom's Taxonomy, including remembering, understanding, applying, analyzing, evaluating, and creating.

A dry run of the mathematics achievement test questionnaire was conducted involving 30 grade seven students enrolled in Anibongon Integrated School, Sta. Rita, Samar. The results were used to determine validity and reliability indices of the test. To determine the internal consistency of the test, Kuder-Richardson

Formula 20 (KR-20) was used since each test item was scored right or wrong (Ary et al., 2009). KR-20 yielded a value of 0.905, suggesting an excellent or a very high internal consistency. Item analysis was also conducted; in particular, item difficulty level, item discrimination index, and effectiveness of distractors were investigated.

Data Analysis

We used tabular presentations of the data we collected along with descriptive analysis. The data were presented, examined, and understood using descriptive statistical methods like percentages, frequency distribution, and means. t-Test for Independent Samples was used to determine whether significant differences exist between the mean pretest scores and between the mean posttest scores of the experimental and the control group. Likewise, t-Test for Dependent Samples was utilized to determine whether a significant difference exists between the mean pretest score and the mean posttest score for each of the control and the experimental group. Cohen's d was employed to determine the standardized difference between two means. This is a measure of effect size which indicates the magnitude of the effect of an intervention or a strategy. Microsoft Excel and the Statistical Package for the Social Sciences were used to process the data.

RESULTS AND DISCUSSION

The results of this study are presented in five parts to address its objectives. Subsequent discussions include the Mathematics achievement of the students taught with and without mathematical games, difference between the pretest scores of the students taught with and without mathematical games, difference between the pretest and posttest scores of the students taught with mathematical games, difference between the pretest and posttest scores of the students taught without mathematical games; and difference between the posttest scores of the students taught with and without mathematical games.

Table 1. Achievement test scores of the students in the pretest and posttest taught with and without mathematical games

Achievement Score	Experimental Group (With mathematical games)				Control Group (Without mathematical games)			
	Pretest		Posttest		Pretest		Posttest	
	F	%	f	%	f	%	f	%
Above the mean	5	35.7	8	57.1	5	35.7	5	35.7
Below the mean	9	64.3	6	42.9	9	64.3	9	64.3
Mean Score	21.4		26.3		23.2		28	

As shown in the table, the mean scores in the achievement test of both groups increased. For the experimental group, mean score increased from 21.4 to 26.3 while, in the control group, mean score increased from 23.2 to 28. When described as to whether scores fall above or below the mean in the pretest and in the posttest, only the experimental group shows change in the distribution of scores but only slightly. In this group, 9 students scored below the mean while 5 scored above the mean in the pretest. In the posttest, the number of students that obtained scores above the mean increased to 8. On the other hand, no change in the distribution of scores was observed from the control group. In both pretest and posttest, 5 students scored above the

mean while 9 students scored below the mean. In addition, these results signify that with or without the mathematical games are both effective in the teaching and learning process in improving the students' mathematical achievements.

Table 2 shows the comparison of the pretest scores of the experimental and control group utilizing an independent t-test. This step is important to show that the groups are comparable in terms of achievement level prior to their participation in the experiment. Equality of pretest scores between the two groups is an important condition to be satisfied before comparing the posttest scores at the end of the experiment. The result of the independent t test indicates that the mean pretest score of the experimental group (mean = 21.4) is not significantly different from the mean pretest score of the control group (mean = 23.2), with a p-value of 0.534.

Table 2. Comparison of pretest scores of the students taught with and without mathematical games

Group	Mean Score	df	t	p-value	Interpretation
Experimental (With mathematical games) (n = 14)	21.4	26	2.056	0.534	Not Significant
Control (Without mathematical games) (n = 14)	23.2				

This suggests that the experimental group was comparable to the control group with respect to Mathematics achievement prior to the two groups' participation in the study. The comparability of the two groups is important because it establishes basis for the comparison of the posttest scores of the two groups or the effect of using mathematical games on the mathematics achievement of the students.

Table 3. Comparison of the pretest and posttest scores of the experimental group (with mathematical games)

Test	Mean Score	df	t	p-value	Interpretation
Pretest (n = 14)	21.4	13	2.160	0.003	Significant
Posttest (n = 14)	26.3				

Table 3 shows the comparison of the pretest and posttest scores of the experimental group using dependent t-test. This statistical test provides information whether students in the experimental group had significant gains in achievement test scores. This also shows whether Mathematics teaching that integrates games is effective in improving achievement level. Using dependent t-test, the comparison of the pretest and posttest scores of the experimental group yielded a significant result, with a p-value of 0.003. The group's mean posttest score (mean = 26.3) is significantly higher than its mean pretest score (mean = 21.4). This means that incorporating

games in teaching Mathematics substantially improved the group's Mathematics achievement. This further suggests that this method of teaching is effective. This result is similar to those of Taclay (2013) and Rondina and Roble (2019) which indicated that students exposed to mathematical games demonstrated significantly higher mean posttest scores. The positive effect of the mathematical games in this study can be attributed to several factors. First, games motivate students to learn and provide students enjoyable learning experiences. Second, games engage students in various ways. Third, games provide personalized and self-regulated learning. And fourth, games create a friendly setting for learning where students do not fear failure or committing mistakes (Plass, Homer, & Kinzer, 2015).

Table 4. Comparison of the pretest and posttest scores of the control group (without mathematical games)

Test	Mean Score	df	T	p-value	Interpretation
Pretest (n = 14)	23.2	13	-3.552	0.004	Significant
Posttest (n = 14)	28.0				

Table 4 shows the comparison of the pretest and posttest scores of the control group using dependent t-test. This statistical test shows whether students in the control group had significant gains in achievement test scores. Results illustrates whether teaching without mathematical games is effective in improving Mathematics achievement. Utilizing a dependent t-test to compare the pretest and posttest scores of the control group, significant differences were also found, with a p-value of 0.004. The group's mean posttest score (mean = 28.0) is significantly higher than its mean pretest score (mean = 23.2). This shows that the conventional method of teaching substantially increased the mathematics achievement of the group, and hence, effective. This is likewise similar to the result of Taclay (2013) which demonstrated that students exposed to the traditional method of teaching have shown significantly higher mean posttest score, indicating the effectiveness of the method. This further suggests that the traditional method of teaching cannot be completely replaced by mathematical games. The result provides evidence that there is still benefit from using the traditional method.

Table 5. Comparison of posttest scores of the students with and without mathematical games

Test	Mean Score	Pooled SD	df	t	p-value	Interpretation
Control (Without mathematical games) (n = 14)	28.0	9.8	26	2.056	0.648	Not Significant
Experimental (With mathematical games) (n = 14)	26.3					

Cohen's d Effect Size = 0.175 (Small Effect)

Table 5 shows the comparison of posttest scores of the control and experimental group employing an independent t-test. Further analysis using Cohen's d is also presented for the effect size. The outcome indicates that the mean posttest score of the control group (mean = 28.0) is higher than the mean posttest score of the experimental group (mean = 26.3). Independent t-test result, however, indicates that the difference between the mean scores is not statistically significant, with a p-value of 0.648. Hence, it can be stated that the method of using games in teaching Mathematics and the conventional method are comparable in terms of effectiveness, despite the conventional method yielding the higher mean. To corroborate this result, Cohen's d, a measure of effect size, is computed. Effect size can help determine how much more effective is one intervention than another. The computed Cohen's d shows an effect size of 0.175 which means that the mean posttest score of the control group is 0.175 standard deviations above the mean posttest score of the experimental group. This is, however, interpreted as a small effect or negligible, and thus, the two methods of teaching are equally effective.

Moreover, this result is one of the few cases where mathematical game is not superior to the traditional method of teaching. It can be noted that most studies investigating the effect of game-based learning on Mathematics achievement have shown that mathematical games are generally more effective than the traditional ones (D'Angelo, Rutstein, & Harris, 2016; Rondina & Roble, 2019; Taclay, 2013). This may be attributed to the difficulty level of the mathematical concept being taught. Mathematical games are usually helpful in making abstract or difficult concepts more understandable. Traditional teaching method can be as effective as mathematical games when concepts taught are not difficult to comprehend. In this study, the featured concept is fundamental operations on integers and rational numbers which is considered basic or foundational knowledge for learning complex mathematical concepts.

CONCLUSIONS

In view of the findings of the study, it is concluded that teaching with mathematical games, including MathDoku, DaMath, number puzzle, magic square, and outdoor amazing race, is effective in improving the mathematics achievement of the students, with respect to knowledge of fundamental operations on integers and rational numbers. Notably, teaching without mathematical games also showed effectiveness in improving students' achievement on the same mathematical concepts. Likewise, these strategies can be used to complement one another when teaching number operations and closely related topics. While teaching without games can be used to directly teach mathematical rules and concepts, teaching with mathematical games can help create novel learning environment or experiences that can promote active learning to students. Finally, discounting the fact that the topic coverage for the lessons taught is relatively narrow, this study contradicts most studies showing that instruction incorporating mathematical games is generally more effective in enhancing students' Mathematics achievement. Moreover, teachers may incorporate these mathematical games in teaching fundamental operations on integers and rational numbers to make learning more interesting and engaging to the students. Since this study only considered the collective effect of the mathematical games comprising the treatment, more studies may be conducted to determine the individual effect and its relative contribution to students' Mathematics achievement. Researchers may also explore the effectiveness of these games in teaching similar topics in higher grade levels to determine their adaptability or range of application. In addition, further experiments may consider the difficulty of the topic or concept

taught to determine the effectiveness of teaching with mathematical games than teaching without mathematical games.

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