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Effectiveness of Game-Based Learning Instructional Materials in Enhancing the Mathematics Performance of Grade 8 Learners

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ABSTRACT

This study aimed to improve grade 8 participants' capacity for mathematical thought. The researchers developed the students' capacity to think, comprehend underlying ideas, and solve challenging mathematical problems when they learn mathematics through games. While having fun, educational games encourage students to come up with original ideas and push them to learn more quickly. Instructional games only make arithmetic ideas easier for pupils to comprehend and retain. Their confidence is increased by the conversations students have with one another to provide a lasting learning effect. Together, games help learners feel powerful and on par with their peers. The quasi-experimental methodology of the current research utilized the group design of non-equivalent pretest and posttest, comprising the experimental and comparison groups. The researchers developed the instruments validated by the experts (head teacher and master teachers) from the City Schools Division of Cabuyao. Participants' mean performance scores in the pretest and posttest data were compiled and contrasted. Using the paired sample t-test and Cohen's d, it was evaluated whether the mean scores on the pretest and posttest differed statistically significantly. The outcome from the posttest frequently improved over those from the pretest. Pretest and posttest results showed a discernible difference, showing that game-based learning instructional materials might assist students in enhancing their mathematical problem-solving abilities. Game-based learning using different game application tools emphasizes the importance of strengthening the foundation of math concepts and the mathematical proficiency to solve various problems in math.

Keywords: *Game-based Learning, instructional materials, performance of the learners*

INTRODUCTION

Instructional materials are components that make mathematics teaching and learning enjoyable and rewarding. Today's successful mathematics teachers can use game-based learning instructional resources to express ideas and pique students' interest. Mathematics teachers consider how they may use game-based learning instructional resources to teach arithmetic to students. The teachers can overcome this challenge by using technology-based programs that have been scientifically verified and are based on research on how students acquire specific topics (Clements & Wright, 2022). Teaching is only complete once knowledge has been successfully conveyed. Most situations were connected to instructional materials utilized in the learning process rather than instructor efficacy or teaching quality.

When the Philippines took part in PISA for the first time in 2018, among the 79 participating economies, it came second-to-last in science and mathematics. With a

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significant socioeconomic divide, most Filipino pupils still need proficiency in any of the three PISA courses. Some students even experienced difficulties in understanding and applying mathematical concepts, formulas and processes (Domondon, Pardo and Rin, 2022). This correlated by Agup and Agup (2020) who stressed that mathematics is generally perceived as challenging and difficult. These results underline how urgently the Philippines' basic education standards must be raised.

Teachers employ various online teaching materials to encourage students to learn. In addition, the relevance of instructional resources to the lesson's goal and their simplicity are essential factors to consider when using instructional materials to improve a learner's performance.

The Framework for 21st-Century Learning (P21) is required to ensure that students are prepared for the twenty-first century. Access to information, usage of technological tools, and collaboration are all aided by the dominance of digital media. Mathematical learning necessitates several instruments that enable pupils to actively increase their understanding of mathematics. Teachers strategically employ suitable tools in mathematical training (Santos, 2017).

Since technology makes it possible for students to learn anytime, anywhere, online education programs are increasingly considering the quantity and diversity of students, as well as the many paths and ways they can choose to learn (Levine, 2018), as well as the learning environment (Friedman et al., 2022).

Although game-based learning opens up new possibilities for effective learning, there are still certain obstacles to overcome, such as how to help students manage their efforts and methods for a specific goal (Chen, 2019). This research created a game-based bargaining mechanism and evaluated its effects on student learning in terms of performance and conduct throughout the learning process.

The impact of digital games and the notion that kids would be learning valuable skills influenced how instructors and researchers viewed games, leading many to believe that they could provide helpful and appealing new teaching methods. Games are becoming a viable replacement for traditional teacher lectures as technology and computer graphics improve.

Academic studies have tended to concentrate more recently on the incorporation of game-based learning into instruction. Recently, teachers have used some instructional tools to improve the quality of their students' experiences and the effectiveness of their education. Many gaming apps have been developed using technology to enhance teaching and learning. A few benefits that make game-based understanding desirable for this new standard of knowledge include social-emotional development through improving memory function, familiarity with computers and simulations, developing "soft" skills, and strategic thinking and problem-solving. Students can learn basic number concepts through games, including counting in sequence, one-to-one correspondence, and computing techniques. Students might be encouraged to explore crucial mathematical subjects by playing fun math games.

This course aims to provide students with a framework and process for problem-solving to achieve particular goals. While attaining that aim may be difficult, the difficulty makes gameplay enjoyable. Teachers are attempting to exploit the use of technology to boost and maximize education, particularly this new normal learning, as technology rapidly

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advances. Using game-based-learning instructional materials is not easy, especially with distance learning. With good preparation, however, teachers can provide more effective mathematics instruction to their learners with the use of game-based instructional materials.

METHODOLOGY

The study used a quasi-experimental research design. Randomization is absent type of study design. Researchers frequently give both groups a pretest to make sure the groups are comparable to one another. Essentially, a pretest assesses whether the comparison and experimental groups are equivalent at the beginning (Lodico et al., 2006). Mangal and Mangal (2013) stated that a quasi-experimental style of research design, which frequently involves score performance comparisons, looks at the ability to produce results that appeared to be more or less accurate.

The experimental and comparison groups are the two distinct groups involved in this design. The comparison group only receives the pretest and posttest, whereas the experimental group receives the pretest and posttest (Yazon et al., 2019). The experimental group in this study received game-based learning tools, while the comparison group received conventional mathematics instruction. The students of Southville I Integrated National High School in Grade 8, SY 2021–2022 are the participants. They were handled by the researchers, which eliminates the "teacher-factor." A coin was tossed to determine which of the sections belonged to the comparison group (head) and the experimental group (tail). The experimental group was section Obedience, whereas the comparative group was section Generosity. The distribution of the participants is shown in Table 1.

Table 1
Distribution of the student participants

Group	No. of Students	No. of Blind Participants	No. of Actual Participants
Experimental	40	10	30
Comparison	45	15	30
Total	85	25	60

The actual respondents of this study were 60 participants, each of which has 30 students. While the comparison group received a traditional education, the experimental group received arithmetic instruction using game-based learning resources. Although the 25 blind participants took part in teaching and learning, the data analysis for the research did not consider their performance.

The instrument used in this research was a validated teacher-made test for the third grading period in selected topics in Grade 8 Mathematics. The format, design and operability, presentation and organization, and accuracy of the teacher-created questionnaire were all evaluated by the content validator. It was built using the Table of Specifications (TOS). The researchers used DepEd tests to create a more reliable instrument.

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The researchers used game-based learning instructional materials, a pretest, a formative test, and a posttest. The game-based learning instructional materials use any online application applied to the lesson/topic, such as GeoGebra, Quizizz, Kahoot, Quizlet, and Jamboard. The researchers created the game apps' questionnaires, validated, and highly accepted by the Head Teacher and Master Teacher. The pretest was based on the periodic test before the third grading period began. The formative tests were adapted from the Department of Education's approved modules, with minor revisions gleaned from various sources as indicated by the Head Teacher and Master Teachers. The researchers created the posttest, validated and highly accepted by the Head Teacher and Master Teacher from Southville I Integrated National High School's Mathematics Department and usually related to the pretest.

The experimental group employed game-based learning instructional materials such as GeoGebra, Quizizz, Kahoot, Quizlet, and Jamboard throughout the learning process. The teacher produced a questionnaire that applied to the course/topic when presenting the lesson using the mentioned application. The instructor pushed the students to exercise critical thinking. The instructional resources for game-based learning were used to encourage critical thinking and boost their excitement for problem-solving.

The teacher began to use the stated program in lessons such as Four Classifications of Mathematical System throughout the third quarter. The Triangle Congruence Postulate and Proving two triangles are congruent are examples. Before moving on to the proper lesson, the Kahoot application was used to analyze the problem. The engaging question is, "What area of San Pablo City Cathedral represents?" The teacher used the Kahoot app to show an image of San Pablo City Cathedral, and the students selected the correct answer using their cellphones, laptops, or tablets. After giving motivation, the teacher continued to discuss the lesson, and after the discussion, the teacher used another app, Jamboard apps, to group their students' activities to collaborate. The students illustrated Rays XY, YX, ABC, K, and line segment MN in this activity. By using Jamboard, the students collaborated with their classmates. The students opened the Geogebra worksheet or form to construct, based on the above conditions, the following postulates and theorems, after the teacher used Geogebra for the students' individual performance: 1) A line is determined by two unique points. 2) The CD = DC if line m comprises the points C and D. 3) The measure angles ABD plus CBD equal the measured angle ABC if point D is located within angle ABC. 4) Measure angle AFC equals measure angle BFD if the AB and CD cross at point F. 5) If a point is non-collinear, or outside of a line, then the point and the line are both contained in the same plane. After the individual performance, the teacher assessed the students using Quizizz. After providing students with a unique access code, the teacher created a question related to their lesson and presented it live as a time competition. After the students completed the quizzes, they could review their answers. The data was also put into a spreadsheet to give the teacher a clear picture of students' performance.

The data were gathered through various formative tests and analyzed using mean and standard deviation. The t-test of independent samples was used to evaluate whether there was a significant difference between the mean scores on the formative tests and the posttest scores for the two groups. The t-test for dependent samples was utilized to see if

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there was a statistically significant difference between each group's mean scores for the pretest and posttest.

The amount of the mean comparison and experimental groups' differences in performance on the formative and posttest was evaluated using Cohen's Effect Size Estimation. The following interpretation was applied to estimate the mean difference's influence size.

Table 2
The Cohen's d Effect Size Standard/ Interpretation

Effect Size	Cohen's Standard Interpretation
0.0 - 0.2	Small
0.3 - 0.5	Medium
0.6 - 0.8	Large

RESULTS AND DISCUSSION

This section contains the different tables that present the results to determine the effectiveness of game-based learning instructional material in enhancing the mathematics performance of Grade 8 learners.

Table 3
Pretest mean scores of the students in the experimental group and comparison group

Group	Mean	Std. Dev.	Descriptive Interpretation
Experimental Group	8.73	1.17	Very Low
Comparison Group	8.73	1.17	Very Low

Legend: 36 – 40 = Very High; 30 – 35 = High; 20 – 29 = Average; 10 – 19 = Low; 0 – 19 = Very Low

The pretest mean score for the experimental and comparison groups is shown in Table 3. Both groups had the same mean scores of 8.73 and standard deviation of 1.17, which can be construed as very low based on the mandated definition of identical scores. A slight standard deviation suggests that the pupils' test results were pretty comparable. In this study, pairing the selected participant was done using the data results.

According to Guskey (2015), teachers use pre-tests to measure students' knowledge before instruction. The teacher requires this information to arrange appropriate activities for each lesson. The goal of the pretest is to provide a performance baseline against which student growth or learning gains may be measured. According to Magdalen (2011), teachers and experts should concentrate on finding the student's least learned lesson as a foundation for applying instructional tools or materials in the classroom. The comparison and experimental groups were provided with various instructional materials and lessons to gain the necessary knowledge and expertise in this study.

Table 4
Formative test mean scores of the students in the two groups

Group	Mean	Std. Dev.	Descriptive Interpretation
Experimental Group	50.50	3.78	High
Comparison Group	40.60	3.86	Average

Legend: 51.0 – 60.00 = Very High; 41.0 – 50.9 =High; 31.0 –40.9 = Average; 21.0 –30.9 = Low; 10.0 – 20.9 = Very Low.

Table 4 shows that the formative test for the experimental group's mean score was 50.50 and a standard deviation of 3.78, regarded as high. In contrast, the comparison group's mean score was 40.60, and the standard deviation of 3.86 is regarded as average. The group that used game-based learning instructional materials outperformed the group that used traditional learning methods, as seen in the mean difference of 9.9. The standard deviations for the experimental and comparison groups, 3.78 and 3.86, respectively, were also reasonably close.

The outcomes of the formative tests demonstrated this experimental group did better than the comparison group. According to research, students can quickly examine what they did and play around with the concepts while using game-based learning teaching tools.

The usage of instructional materials had a substantial impact on students, as seen by the formative test results in Salvador's (2011) study; students exposed to produced instructional materials outperformed those subjected to the conventional mode of instruction in terms of mean test scores.

In the conventional lecture format, the teacher expects the students to accept the information presented to them without question, claimed Abdi (2014). There is little space for individual research and questions raised by students or even participation in group activities because the instructor's main objective is to communicate ideas and comprehension to the passive learner. The teacher also discourages pupils from exploring or analyzing statements.

The formative test results indicate that the experimental group outperforms the comparison group. Students may quickly examine their accomplishments and play around with the concepts when using game-based learning instructional materials.

Table 5
Posttest mean scores of the students in the two groups

Group	Mean	Std. Dev.	Descriptive Interpretation
Experimental Group	16.53	1.22	Average
Comparison Group	14.27	1.39	Low

Legend: 26 – 30 = Very High; 21 – 25 = High; 16 – 20 = Average; 10 – 15 = Low; 0 – 9 = Very Low

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Table 5 shows the posttest mean scores for the learners in comparison and experimental groups. This experimental group had a mean rating of 16.53 and a standard deviation of 1.22, showing an average result as compared to the comparison group, which mean rating of 14.27 and a standard deviation of 1.39. It demonstrates an average difference of 2.27 performance between the experimental and the comparison group, which was taught using conventional education methods.

According to Table 5, the comparison group's posttest score was 0.17, more evenly distributed than the experimental group, with standard deviations for the experimental and comparison groups being 1.22 and 1.39, respectively. It suggests that the scores of the kids in these groups are quite comparable.

Students in the test group had success with the educational materials that included games for learning (Kahoot, Quizizz, Quizlet, Jamboard, and Geogebra). It is due to the learner's usage of digital technologies; they were taught values and skills and how to feel more competent. Rather than explaining the concepts, digital technologies enable them to grasp each lesson and comprehend the concept's significance. Students can be motivated and interested in new content areas by using technology.

To establish whether or not an independent sample t-test was conducted to establish whether there was a statistically significant difference between the mean formative assessment scores of the experimental and comparison groups. Table 6 presents the outcomes.

Table 6

Test of significant difference between the formative test mean scores of the two groups

Group	Mean	Mean Difference	df	t-value	Cohen's d	Effect Size
EG	50.50	9.90	58	10.036*	2.59	Large
CG	40.60					

Legend: EG = Experimental Group; CG = Comparison Group; df = Degrees of Freedom Significant at .01 level

According to the results in Table 6 [t(58) = 10.036, mean-diff=9.900, p-value<0.01], the mean formative test results were significantly different between the experimental and comparison group conditions. On the examination of students' mean performance results, using game-based learning instructional materials had a beneficial impact on their performance, and the effect of technology can be seen in the students' progress outcomes.

The Cohen's d affects size estimation results because the test had demonstrated significance. The calculated effect size was 2.59, considered high for both the comparative and experimental groups. It suggested that the formative test's mean difference between the two groups' means had a sizable effect size. The null hypothesis that no detectable change was therefore accepted.

According to the findings of Al-Kabi and Shardah's (2010) formative test, there was a need to improve teaching educational techniques through the use of technologies that will enhance educators' ability to deliver knowledge in comparison to traditional ways.

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Studies show that after using GeoGebra, students could comprehend the concept of mathematical series convergence (de Oliveira Lino Franchi & Moura Fonseca, 2016). They added that extensive visualization provided by this software, students could also comprehend many depictions of the same mathematical topic.

The formative should smear not to the assessment but to the function that confirmation engendered by the assessment serves (William, 2013). Many researchers have made several attempts to understand why and how formative assessment affects students' thinking processes (Rakoczy et al., 2013). Formative assessments were feedback-generating that generated smaller incentives than summative which graded (Shiomi et al., 2012). Furthermore, it aided in selecting and remediating students' inadequate, and McMillan (2010) argued that recurrent use of formative assessment allowed students to have a more excellent grasp of learning materials.

Table 7
Test of significant difference between the posttest mean scores of the two groups

Group	Mean	Mean Difference	Df	t-value	Cohen's d	Effect Size
EG	16.53	2.267	58	6.708*	1.723	Large
CG	14.27					

Legend: EG = Experimental Group; CG = Comparison Group; df = Degrees of Freedom
Significant at .01 level; Cohen's d: 0.01-0.49; Small: 0.50-0.79; Medium; 0.80-2.99; Large

Table 7 displays the outcomes of a paired sample t-test that is accustomed to contrast the posttest mean scores of the experimental and reference groups. As seen on the table, with a condition [t(58) = 6.708, Mean-Diff=2.267, p-value<0.01], the experimental group, which received instruction using game-based learning instructional materials, had a higher posttest mean score of 16.53 than the comparison group, which received instruction using traditional methods.

Since the test had shown significance, the size of the effect difference was computed using Cohen's d. The calculated effect size of 1.723 was accepted by both the experimental and comparison groups, which was substantial, to be significant. It indicated the mean difference between the posttest mean scores of the two groups had a substantial impact size. The null hypothesis, that no detectable change, was therefore accepted.

The outcomes revealed a significant performance gap between students taught mathematics through game-based learning resources against standard foundation teaching materials. The students who employed mathematics game-based learning outperformed the group of students taught through traditional base teaching, with mean scores of 16.53 and 14.27. It is consistent with Heid's (2005) Instrumentation Theory, which defines instrumental origin as forming a functioning relationship between the user and the tool. It is not how technology is used or by whom that makes a difference. In the presence of technology, learning takes on a new meaning. Learning mathematics is reliant on the student's ever-changing connection with technology.

The findings suggested that learners in the experimental group learned more through game-based learning methodologies than students taught with existing materials. The fun of utilizing gamification to teach arithmetic has generated a new learning environment that has expanded kids' imaginations. The joy they felt inside led to experiential learning beyond reading and listening. Taking advantage of interactive learning also boosts students' motivation and engagement with study content. Multiple senses are engaged during each lesson with game-based learning study material, which activates various digital tools, making it easier for students to consume and remember. Teachers can utilize interactive learning platforms to keep track of a student's class progress and make their lessons more engaging so that students stay in class and continue learning at home.

Meanwhile, a posttest assesses student progress. The teacher can compare these two assessments to track their students' progress (Kelly, 2017).

A paired samples t-test was conducted to ascertain whether there was a statistically significant difference between the and posttest mean scores for both the experimental and comparison groups. Table 8 presents the outcomes.

Table 8

Test of significant difference between the pretest and posttest mean scores of each group

Group	Test	Mean	Mean Difference	Df	t-value	Cohen's d	Effect Size
Comparison	Pretest	8.73	-5.53	29	-	4.312	Large
	Posttest	14.27			18.082**		
Experimental	Pretest	8.73	-7.80	29	-	6.526	Large
	Posttest	16.53			18.082**		

Cohen's d: 0.01-0.49 (Small); 0.50-0.79 (Medium); 0.80-2.99 (Large) Significant at .01 level

Table 8 displays the test for a statistically significant difference in the mean scores for the two groups' pretest and posttest. The comparison and experimental groups scored, on average, 8.73 on the pretest, which revealed the outcomes. The comparison group's mean score was 14.27, whereas the experimental earned mean was 16.53. The difference between the two groups Cohen's d effect sizes is 6.526 for the experimental and 4.312 for the comparison group. A greater mean difference of -7.8 in the experimental group implies that using game-based learning instructional materials increases student performance. Students gain a sense of success from mastering new knowledge and skills through online learning resources and become motivated to learn even more new things. If this technique is used in the future, students' academic achievement will improve. The lifespan of attention varies, but it is generally short. It is why, regardless of how eager students are to grasp the materials, they will become bored when teachers regularly apply the same teaching approaches. In an interactive classroom, this is impossible to achieve. Interactive learning is possible with various teaching and learning styles and techniques. There are several options for fresh learning materials and technologies on the internet, allowing teachers to spice up

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their students' learning experiences. Interactive learning has a fantastic feature: it is adaptable. There are numerous alternatives available to it. Finally, the fact that it is engaging and enjoyable is among the most persuasive justifications for why students value game-based learning. When given a chance to work together with peers and teachers, exchange ideas, and use technology to study, students have more fun. Interactive learning offers more activities and tools for acquiring the same information than traditional approaches, which are frequently dull and monotonous. Their motivation and engagement levels consequently rise. Students may study using various technologies thanks to interactive learning, which allows them to be creative and control how they learn.

According to Salkind (2010), a pretest is administered to the control and experimental groups before administering the therapy in a pretest and posttest design. To evaluate the outcomes of the pretest and posttest, both groups take a posttest following therapy. The t-test for independent samples was perhaps utilized to establish whether there is a statistically significant difference in the growth score means of just two groups.

CONCLUSIONS

Given the study that has been done, it is clear that adopting game-based learning mathematics instructional in the classroom helps students reach their mathematical learning objectives more quickly and effectively.

In addition, 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. As a result, it was envisioned that learning designers and math instructors would create the resources by incorporating technology into the teaching and learning process. Learning games are used to provide students with a diverse learning environment.

RECOMMENDATIONS

It is recommended to use the game-based learning-teaching resources throughout the exercises to keep their attention in each session. Teachers' use of game-based learning instruction can be continued by encouraging the production and updating of instructional resources in all areas.

ETHICAL STATEMENT

This study focuses on the participation of grade 8 students from Southville 1 Integrated National High School and information provided by respondents; ethical considerations have been addressed. It is crucial to consider these concerns to protect respondents' security and privacy. The main ethical concerns that were taken into account during the research process include consent, confidentiality, and data protection. All necessary information were appropriately communicated, and the study's goal was to obtain respondents' agreement. Through a clear explanation of the crucial information, the respondents understood their involvement in the study's process. They were assured that they were treated equitably and that the knowledge acquired were kept private. Therefore, only the data necessary to address the particular study topics were brought to light.

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