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IMPROVING MATHEMATICS PERFORMANCE USING GAME-BASED LEARNING

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ABSTRACT

This study aimed to improve the mathematics performance of Grade 9 students through game-based learning interventions. The results indicated that game-based learning positively impacted students' mathematics performance, as both the controlled and experimental groups showed improved scores in the posttest. While there was a significant difference in the pretest scores between the two groups, indicating initial variations in mathematical proficiency, there was no significant difference in the posttest scores, suggesting that both traditional teaching methods and game-based learning were equally effective in enhancing mathematics performance. The study recommends integrating personalized learning, fostering collaboration, exploring gamified assessments, involving parents, providing feedback, and ensuring sustainability and accessibility in game-based learning initiatives. These findings contribute to understanding game-based learning's impact on mathematics education and provide practical recommendations for educators and stakeholders.

Keywords: Game-based Learning, Mathematics Performance, Grade 9 students, Experimental Research Design

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INTRODUCTION

Mathematics is a science that helps us understand the world around us and provides an effective way of building mental discipline (The Scientific World, 2018). Waqar (2020) states that children who know math can more reliably recruit certain brain regions and have more gray matter in those regions. In the case of the Dominican Republic, the PISA report (2018) showed that the achievement scores of students in mathematics were recorded as the lowest and were ranked last (Organization For Economic Co-Operation and Development, 2020). The same was true for students in South Africa's Mpumalanga province's Kwagga West Circuit, Nkangala district. Their poor performance in the subject hurts them and keeps them from progressing to the following grades (Mabena et al., 2021).

Mathematics is a general subject taught in primary and higher education in the Philippines. Students were expected to understand and appreciate its principles as they were applied in problem-solving, critical thinking, communicating, reasoning, making connections, representing ideas, and making decisions (K to 12 Basic Education Curriculum). It was crucial, and, as a result, almost every field required it as a subject, claim Blömeke and Delaney (2014). However, there was still evidence of poor performance in this area, as shown by a review of national surveys conducted by the Bureau of Education (BE).

Llego and Tamoria (2021) stated that the Philippines scored the second-lowest in mathematics among the 79 participating countries and economies, according to the 2018 Programme for International Student Assessment (PISA). According to the 2019 Southeast Asia Primary Learning Metrics (SEA- PLM) survey, many Filipino students also performed poorly. Globally and locally, student math performance has been a big concern. In general, math performance among students was poor. On the contrary, based on the findings of Bandoja (2017), game-based learning as a teaching technique significantly increases pupils' math performance.

According to Pho and Dinscore (2015), students can interact with educational materials playfully and engagingly with motivational psychology incorporated into game-based learning. Traditional games include rivalry, rewards, points, and feedback channels. These ideas were gaining popularity in libraries and higher education to motivate students to learn. Game-based math learning boosts students' reasoning ability, understanding underlying concepts, and solving complex math problems. Educational games encourage students to find creative solutions and accelerate their learning, having fun all the while (Integra Marketing Team, 2021). Furthermore, in the study of Rauscher (2018), game-based instruction could offer a fresh framework for learning. Using games in the classroom encourages students to stretch to new ways of thinking, which enhances their performance on tests and their capacity for higher-order thinking.

The findings also indicated that non-digital game-based learning motivated and enhanced learning outcomes. Additionally, these games' pedagogical value extends beyond the teaching of mathematics. It could be easily modified for other subject areas (Naik, 2014).

This study aimed to determine if game-based learning would improve the mathematics performance of Grade 9 students. The researcher seeks to create a proposal that would encourage a new paradigm in teaching that caters better to the student's learning. The tactics now being employed in the classroom might be strengthened by this research, which would improve both teachers' paradigms and students' performance. As a result, the study's findings will serve as the foundation for a proposal to implement game-based learning at Olongapo City National High School (OCNHS) to improve students' math performance.

RESEARCH METHODOLOGY

Research Design

The researcher utilized a group pretest-posttest quasi-experimental design to systematically conduct the classroom-based action research and gather the data and information. The experimental group used "game-based learning," and the control group used "traditional face-to-face learning."

According to Cornell and Drew (2022), a quasi-experimental design is a type of experimental research that is used when researchers want to study the effects of a variable/treatment on different groups of people (Asio, 2021). In quasi-experimental designs, frequently used in behavioral research, the researcher used a pretest-post-test design.

The pretest-post-test design was used by the researcher since the aim of this study was also to determine the effect of using game-based learning on the student's performance in Mathematics. The pretest and posttest scores would exhibit the difference in the test scores before and after the treatment.

Respondents

The respondents of this research were the grade 9 students from the STE-Lavoisier and Boyle class of the researcher, which includes two sections of grade 9 in the school year 2022-2023 at OCNHS. The population would undergo a pretest and posttest before and after the class
session.

Table 1. Frequency and Percentage Distribution of the Student-Respondents

Groups	**Frequency**	**Percentage**
Controlled	32	50.8
Experimental	31	49.2
Total	**63**	**100**

The table displays the frequency and percentage distribution of the student-respondent profiles based on two distinct groups: the Controlled group and the Experimental group. The study encompassed 63 student respondents.

In the Control group, 32 students were present, accounting for 50.8% of the total student respondents. On the other hand, the experimental group was comprised of 31 students, representing 49.2% of the total student respondents.

These figures elucidate the distribution of students across the two groups within the study. The control group slightly outweighs the experimental group, which accounts for 50.8% of the total students. The Experimental group constitutes 49.2% of the overall student population.

Research Instrument

The pretest and posttest will be administered at the beginning and end of the educational intervention based on modules produced by the Department of Education

(DepEd) from the designated Most Essential Learning Competencies (MELC). The data collected was the basis for an improvement in student mathematics performance.
The respondents created a journal to identify the effectiveness of game-based learning in increasing the mathematics performance of Grade 9 students. Implementing games related to the topic and developing a lesson plan are factors to consider.

Statistical Treatment of Data

Upon completing the data collection data collection, the data was organized in a Microsoft Excel Sheet. Further analysis was done using the statistical treatments applied in the study. The researcher used the mean formula to determine the arithmetic average among the respondents' scores regarding pretest and posttest results and the effectiveness of game-based learning. A *t*-test for correlated samples was used to compare the means before and after the treatment. This tool also tested the significant difference between the pretest and posttest.

RESULTS and DISCUSSION

This part contains the researchers' results, interpretation, and discussion of the data using the reviewed literature and studies. The data were organized in sequential order based on the problem statement.

Table 2. Mean Distribution of the Student-Respondents Pretest and Posttest Scores

Groups	Test	Mean	SD	MPS
Pretest	Controlled	8.13	3.22	40.63
	Experimental	5.84	2.27	29.19
Posttest	Controlled	15.41	2.60	77.03
	Experimental	15.06	3.01	75.32

Table 1 presents the mean distribution of pretest and posttest scores for the controlled and experimental groups in the study. The data highlights the mathematics performance of Grade 9 students before and after the implementation of game-based learning, incorporating Filipino Traditional Games (*Piko* and *Kadang-Kadang sa Bao*), math-related games (Carousel, Boards-up, and Amazing Race), and computerized games (Hyperlink games).
In the pretest scores, the control group obtained a mean score of 8.13, with a standard deviation of 3.22. This result corresponds to a mean percentage score of 40.63, indicating the students' initial level of mathematical proficiency. On the other hand, the experimental group achieved a lower mean score of 5.84, with a standard deviation of 2.27, resulting in a mean percentage score of 29.19.
The control group had a higher mean pretest score than the experimental group. These scores suggest that the students in the experimental group had a relatively lower level of mathematical proficiency before the intervention compared to the control group.
Following the implementation of game-based learning, both the controlled and experimental groups improved their mathematics performance. The control group achieved a mean score of 15.41 on the posttest, with a standard deviation of 2.60,

corresponding to a mean percentage score of 77.03. Similarly, the experimental group demonstrated progress, obtaining a mean score of 15.06 on the posttest, with a standard deviation 3.01, resulting in a mean percentage score of 75.32. These scores indicate a significant enhancement in the mathematical performance of both groups after implementing game-based learning.

Overall, the results from Table 1 suggest that game-based learning, incorporating a combination of Filipino Traditional Games, math-related games, and computerized games, has positively influenced the mathematics performance of Grade 9 students. Both the controlled and experimental groups displayed improved scores in the posttest, indicating the effectiveness of the game-based learning approach in enhancing students' mathematical proficiency.

Kelly et al., (2013) focuses on designing game-based learning environments for elementary science education. It adopts a narrative-centered learning perspective and explores how game narratives can enhance students' engagement and learning outcomes. The study emphasizes integrating narratives into game-based learning environments to create meaningful and immersive experiences. The findings highlight the positive impact of narrative-centered game-based learning on students' science learning, indicating increased engagement, motivation, and improved learning outcomes.

Table 3. Independent *t*-test on Pretest Scores between Controlled and Experimental Group

Groups	**Mean**	**SD**	***t*-value**	***p*-value**	**Remarks**
Controlled	8.13	3.22	3.249	.002	Significant
Experimental	5.84	2.27			

Table 2 presents the results of an independent *t*-test to compare the pretest scores of the controlled and experimental groups. This test aims to determine whether there is a significant difference in the two groups' pretest performance

The mean pretest score in the controlled group is 8.13, with a standard deviation of 3.22. The experimental group, on the other hand, has a lower mean pretest score of 5.84, with a standard deviation of 2.27.

The *t*-value of 3.249 indicates the magnitude of the difference between the two groups' means. The corresponding *p*-value of 0.002 suggests that the difference is statistically significant. Therefore, there is evidence to support that there is a substantial difference in the pretest scores between the controlled and experimental groups.

The significant difference in the pretest scores indicates that the two groups had different levels of mathematical proficiency before implementing the game-based learning intervention. This difference in performance at the start of the study is essential to consider when evaluating the intervention's impact on the subsequent post-test scores.

Overall, based on the results of this *t*-test, there was a significant difference in the pretest scores between the controlled and experimental groups. This suggests initial variations in the two groups' mathematical performance before the implementation of the game-based learning approach.

Game-based learning is an active teaching and learning approach that incorporates commercial and educational games within the classroom. This approach promotes student engagement and participation, aligning with the learner-centered strategy of active learning. Students are actively involved in various activities, such as answering inquiries, problem-solving, discussing course materials, sharing knowledge, and expressing their cognitive processes.

Table 4. Dependent *t*-test between Pretest and Posttest Scores of the Controlled and Experimental Group

Groups	Test	Mean	SD	*t*-value	*p*-value	Remarks
Controlled	Pretest	8.13	3.22	-10.805	.000	Significant
	Posttest	15.41	2.60			
Experimental	Pretest	5.84	2.27	-17.269	.000	Significant
	Posttest	15.06	3.01			

Table 3 presents the results of the dependent *t*-test, which investigated the significance of the difference between the controlled and experimental groups' pretest and posttest scores. The table provides essential insights into student performance changes from the pretest to the posttest phase.

In the controlled group, the pretest mean score of 8.13 (SD=3.22) was significantly different from the posttest mean score of 15.41 (SD=2.60), as indicated by the *t*-value of -10.805 ($p<0.05$). This significant difference suggests that the control group experienced significant improvements in their mathematics performance after implementing the usual way of teaching. The *p*-value of 0.000 confirms the statistical significance of this improvement.

Similarly, in the experimental group, the pretest mean score of 5.84 (SD=2.27) was significantly different from the posttest mean score of 15.06 (SD=3.01), as indicated by the *t*-value of -17.269 ($p<0.05$). This significant difference indicates that the experimental group also significantly improved their mathematics performance after implementing game-based learning. The *p*-value of 0.000 further supports the statistical significance of this improvement.

Overall, the findings from the dependent *t*-test provide strong evidence that both the controlled and experimental groups experienced substantial improvements in their mathematics performance. The control group showed a mean increase from 8.13 to 15.41, while the experimental group exhibited a mean increase from 5.84 to 15.06. These results highlight the effectiveness of the normal teaching method and game-based learning in enhancing students' mathematics performance.

Table 5. Independent *t*-test on Posttest Scores between Controlled and Experimental Group

Groups	Mean	SD	*t*-value	*p*-value	Remarks
Controlled	15.41	2.60	0.483	0.631	Not Significant
Experimental	15.06	3.01			

Table 4 presents the results of an independent t-test comparing the post-test scores of the controlled and experimental groups. This test aims to determine if there is a significant difference in the two groups' post-test performance after the game-based learning intervention was implemented.

The mean posttest score in the controlled group is 15.41, with a standard deviation of 2.60. The experimental group, on the other hand, has a slightly lower mean posttest score of 15.06, with a standard deviation of 3.01.

The *t*-value of 0.483 indicates the magnitude of the difference between the two groups' means. The corresponding *p*-value of 0.631 suggests that the difference is not statistically significant. Therefore, no substantial evidence supports a significant difference in the post-test scores between the controlled and experimental groups.

The lack of significance indicates that the two groups had similar post-test performance after implementing the game-based learning intervention. This result implies that the intervention did not significantly impact the post-test scores of the two groups.

It is important to note that non-significant results do not necessarily mean the intervention had no effect. Other factors, such as sample size or group variability, could contribute to the need for more significance in this particular analysis.

Wang and Chen (2022), in their longitudinal study indicates that game-based learning interventions lead to significant improvement in posttest scores over time. However, the lack of a substantial difference between the controlled and experimental groups suggests that the interventions did not have a differential impact on post-test performance.

CONCLUSION

The researcher concluded that:

1) The study demonstrated that game-based learning positively impacted the mathematics performance of Grade 9 students. Both the controlled and experimental groups exhibited improved scores in the posttest, indicating the effectiveness of this approach in enhancing students' mathematical proficiency.
2) Significant differences in the pretest scores between the controlled and experimental groups indicated initial variations in the two groups' mathematical proficiency before the intervention. This finding highlights the importance of considering students' baseline performance when evaluating the intervention's impact.
3) The controlled and experimental groups' pretest and posttest scores showed significant differences, indicating substantial improvements in mathematics performance after implementing their respective teaching methods. This result suggests that the standard teaching method and game-based learning effectively enhanced students' mathematical proficiency.
4) There was no significant difference in the post-test scores between the controlled and experimental groups, suggesting that both teaching methods were equally effective in enhancing students' mathematics performance. This implies that the game-based learning approach was as practical as the traditional teaching method in improving students' mathematical skills.

RECOMMENDATIONS

The researcher recommends that:

1) Integration of Game-Based Learning: The study demonstrated the effectiveness of game-based learning in enhancing mathematics performance. Therefore, it is recommended that game-based learning strategies and activities be integrated into the mathematics curriculum of Grade 9 students. This finding can be done by incorporating Filipino traditional games like *Piko* and *Kadang-Kadang sa Bao*, math-related games, and interactive digital tools that engage students in problem-solving and critical thinking. The researcher also recommends trying other traditional games or computerized games.
2) Professional Development for Teachers: To ensure the successful implementation of game-based learning in mathematics education, providing professional development opportunities for teachers is crucial. Teachers should be trained to integrate games into their teaching practices effectively, align game-based activities with learning objectives, and monitor students' progress and
3) engagement. Professional development programs can help teachers acquire the necessary skills and knowledge to utilize game-based learning in the classroom effectively.
4) Ongoing Evaluation and Assessment: It is essential to evaluate the impact of game-based learning on mathematics performance continuously. Regular assessment and monitoring of students' progress will provide insights into the effectiveness of specific games, strategies, or interventions. This data can help identify areas for improvement and inform future adaptations and refinements of game-based learning approaches.
5) Further Research and Exploration: While your study demonstrated the positive influence of game-based learning on mathematics performance, additional research is recommended to understand these interventions' long-term effects and sustainability. Additionally, investigating the impact of game-based learning on different student proficiency or diverse backgrounds can provide valuable insights into the differential impact of game-based learning interventions.

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