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Effects of Game-Based Mathematics Learning on Students' Academic Achievement

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Abstract

In the evolving landscape of education, creative ways to improve student engagement and academic performance are being investigated more and more. Because traditional teaching approaches frequently fail to hold students' attention, educators are forced to look for substitutes that can create a more dynamic and engaged learning environment. Amidst this change, there has been an increase in interest in methods that enhance academic performance while also making learning fun. This study looks into the effects of game-based learning on the academic achievement of Grade 8 students in Mathematics at the University of La Salette High School. Employing a Quasi-experimental design, specifically the pretest-posttest control group design was adopted using two intact groups. A total of 79 students, divided into control (38 students) and experimental (41 students) groups, participated in the study. The control group received instruction through traditional teaching methods such as board works, seat works, assignments and weekly quiz, while the experimental group engaged in various teacher-made, non-digital mathematical games such as games such as Probability Trio: A Three-Game Challenge, Case Quest: The Million Peso Challenge derived from deal or no deal gameshow, Card Category Conundrum, a card game activity and more activities. The main instrument used in this research is a 50-item researcher-made Mathematics Achievement Test. The test underwent a series of steps of validation and the reliability coefficient was also determined (KR-20 = 0.9141). Statistical analysis included paired samples t-tests, independent t-tests, and Cohen's D to determine significant differences in mean scores and the effect size of the game-based strategy.

Results indicated that both groups showed progress from their pretest to posttest scores; however, the experimental group demonstrated a significantly higher average gain of 7.1 compared to the control group's gain of 3. This suggests that game-based learning positively impacts students' mathematical achievement. Pretest scores were comparable between groups, but posttest results revealed a substantial difference favoring the experimental group. The findings highlight the effectiveness of game-based learning in improving academic achievement, with a large effect size indicated by Cohen's D.

In light of these findings, the study recommends that mathematics educators integrate game-based activities into their instruction to enhance student performance and confidence in Mathematics. Continuous updating of activities, curriculum development that incorporates game-based learning, and professional development for educators are also advised. Engaging parents in supporting game-based learning at home and conducting further research with larger sample sizes to explore digital game effects are suggested for future studies.

Keywords: Game-based learning, Mathematics achievement, Mathematics Education

Introduction

Mathematics is an important subject being taught at school. It is one of the core subjects that are necessary for the students to learn in order to build a strong academic foundation which they can use in their studies and daily lives. Mathematics helps students to solve problems, helps them reason logically, and develop other skills in Math that they could integrate into other fields and in real life situations and assist them in understanding a variety of aspects of the fast-changing environment (Tablit, 2019).

Mathematics without doubt remains very important to all disciplines and fields of human work. However, mathematics for many students seems to be difficult because they cannot see the connections of mathematics in their daily lives. At present, the low performance of Mathematics is of concern all over the world, including the Philippines. Several international assessments have shown that Filipino learners have low Mathematics achievement. For instance, based on (DepEd,2019) the National Achievement Test mean percentage score in Mathematics was below the standards. Moreover, for two consecutive assessment years 2018 and 2022 conducted by Program for International Student Assessment (PISA), the Philippines was always placed at the bottom among ASEAN countries who participated. Moreover, according to the results of the Trends in International Mathematics and Science Study (TIMSS) 2019 by the International Association for the Evaluation of Educational Achievement (IEA), Filipino students are not doing well in math. They scored 297 in mathematics, which is much lower than all other participating countries and ranked last out of all 58 countries involved. (Bernardo, 2020). These results show that there is a need to enhance the minimum educational requirements in the Philippines.

Numerous studies and reports have identified a variety of reasons for poor performance in mathematics and researches come up with their suggestions to alleviate the problem as well but still the problem of low performance in mathematics appears in all levels of school education. Some of these researches were focused on identifying factors that constrains the learning of mathematics. Studies revealed that among the reasons for the decrease in mathematics performance is poor foundation of students in mathematics, overcrowded mathematics classes and worn-out mathematics resources, anxiety towards mathematics, poor instructional strategies, insufficient resources for teaching and learning math, negative attitudes of both students and teachers towards math, student apathy and lack of discipline in math, teachers' harshness when teaching math, ineffective teaching strategies, (Mogege & Egara, 2022; Nzeadibe et al., 2019; Okeke et al., 2023), and lack of learners' retention and interest in mathematics (Egara et al., 2021; Nzeadibe et al., 2020; Osakwe et al., 2023). Among those, Poor motivation and lecture methods have been highlighted as some of the problems affecting the academic performance of students in mathematics. (Emaikwu, 2015) revealed some of the problems encountered by learners in mathematics are as a result of their inability to retain mathematical processes which are associated with ways it is being taught in the classroom. On the same issue, (Etsu & Manko 2019) stressed that most teachers of mathematics at secondary levels do not use teaching aids and that most cases of mathematics teachers stick in using lecture methods by doing most of the talking and leave the students as passive listeners. Moreover, researchers such as Bai et al. (2020) noted that mathematics is a difficult topic to learn due to the fact that the content is often presented in a dull and passive manner. Furthermore, Taranto (2022) also noted that many teachers still don't try coming up with activities that can help children explore mathematical ideas. These researches confirmed that math ideas and concepts are delivered to learners in an abstract way which doesn't give children enough chances to engage in practical tasks, problem-solving, and experimenting. According to Euler

(2011) this approach is out of date and no longer relevant and does not consider children's interests and experiences.

Indeed, providing quality education to learners is a challenging task. It requires a significant amount of dedication, diligence, determination, and enthusiasm. Mathematics researchers have been exploring ways to increase students' achievement and interest in mathematical concepts (Osakwe et al., 2023). Moreover, according to (Cabuquin, 2022; Ke, 2016; Karamert & Kuyumcu Vardar, 2021; Digitale (2018) In teaching Mathematics, just as in many other subjects, teachers should make an effort to use instructional strategies that help develop students' math skills, and increase their self-esteem in learning concepts in math and a strategy that encourage students to actively participate in classroom activities in a more competitive, relaxing and fun setting.

One of the promising methods to achieve active participation of students in learning activities and improve their understanding of mathematical concepts would be using games in the classroom (Conmy ,2023). Games are organized activities that include enjoyment, amusement and learning. Games are an innovation in education that add flavor, excitement, challenge and motivation so that pupils enjoy playing the games and at the same time learning the concepts. According to (Cabuquin, 2022) 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. Games are an important medium that makes students more interested in their studies. As a result, students have higher mathematical achievement and promote teamwork (Pantachord, 2021). This is what the Philippine basic education requires, a teaching approach that significantly enhances students' performance.

Game-based learning is the term for using games in the classroom either in parts or as a whole activity, and these games according to (Wong and Osman, 2018) have two types; digital and non-digital games, digital games played on computers, digital mobile games on phone and tablets, or non-digital games, which would be games that are physical and use a game-board or cards and do not use any digital equipment. According to (Plass et al., 2015) Game-based learning has been shown to improve the students' achievements when learning because this is an approach that uses intrinsic and extrinsic motivation to engage, challenge, and provide support for students. Moreover, according to (Khairuddin and Mailok, 2019), the Game-based learning approach is used to stimulate and motivate the students to participate more actively in the learning process, to make the learning process more enjoyable, and to assist the students in comprehending the lessons more effectively. This strategy also enables teachers to include active learning in their lessons, to increase the students' interest and engagement, and to receive instant feedback from the students' performance. Hence, integration of game-based activities into teaching and learning is encouraged.

Academic studies have tended to concentrate more recently on the incorporation of game-based learning into instruction. Although game-based learning opens up new possibilities for effective learning, there are still concerns about how games affect learners (Chen, 2019). According to Plass et al. (2015), and von Gillern and Alaswad (2016) games in the classroom are powerful tools that have the possibility to improve students' achievement. However, in the study of Lim (2021) showed that integrating games in Mathematics teaching does not always result in significant gains in students' Mathematics scores. In his study where he 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. According to (Ariffin, Oxley, & Suliman, 2014) as mentioned by (Pinder, 2021) that

Although game-based learning has been widely utilized by the military, education, marketing, and advertising sectors, its effectiveness as a learning strategy or training tool is still unclear. Moreover, findings from Young et al. (2012) studies on game-based learning recommend further research to confirm that it effectively enhances mathematics education. Furthermore, the literature on game-based learning activities in the teaching of mathematics in secondary level is scarce because majority of the study conducted was in primary and elementary level. And, most of the studies used games in an on-line context and that there is a shortage of studies reporting non-digital applications of the game-based method, despite the advantages it provides when such technologies are not accessible, or when there is no need to introduce digital tools in the class for the specific purpose of the activity (Naik, 2015). Therefore, many areas on non-digital game-based are unexplored. Previous studies using digital game-based learning suggests positive results on students' learning in terms of their performance, but there are still much to be explored on how the non-digital game-based has any effect on the students' performance Yusof, N. A. M., & Shahrill, M. (2021). The present study addresses this gap and examines the significant effects of game-based strategy on the achievement of students in mathematics of high school students. Furthermore, the findings of the study will be used to plan and strategize teaching techniques to fulfill the needs of students and improve mathematics achievement.

Research Questions

1.What is the Pre-test and post test score of the participants under the

1.1. Control Group exposed in traditional learning?

1.2 Experimental Group exposed in game-based learning?

2.Is there a difference between the mean scores of the participants under the control and experimental group on

2.1 Pre-Test

2.2 Post Test

3. Is there a difference in the Pre-test and post test score of the participants of the

31. Control Group exposed in traditional learning?

3.2 Experimental Group exposed in game-based learning?

4.What is the effect size of the game-based strategy on the academic achievement of the participants?

Research Hypothesis

1. There is no significant difference in the pre-test scores of the experimental and control group in the achievement test of Mathematics
2. There is no significant difference in the post-test scores of the experimental and control group in the achievement test of Mathematics
3. There is no significant difference between the pretest and the posttest mean scores of the control group.
4. There is no significant difference between the pretest and the posttest mean scores of the experimental group

Significance of The Study

The findings of this study will be of great help to the following who have anything to do with the success or failure of the students in school; school Administrators, mathematics teachers, students, parents, curric-

ulum developers and future researchers.

School Administrators. This study will be significant to school administrators since they are vital to improving student achievement and meeting the various needs of teachers and students in the classroom. The results can help administrators plan creative teaching strategies by providing information about the effectiveness of game-based learning in mathematics. Administrators can improve instructional effectiveness, pinpoint areas for professional development and teacher training, and more efficiently allocate resources to improve student learning outcomes by incorporating game-based learning.

Mathematics Teachers. This study will be beneficial to the teachers because it provides a basis for mathematics educators towards the adoption of game-based strategy in teaching mathematics. Game based Learning strategy provides teachers with additional resources and tools to teach complex mathematical concepts in a more accessible and interactive manner and at the same time cater different learning styles of students.

Students. This study will be very beneficial to students because it will introduce to different teaching methods other than traditional teaching to enhance their mathematics skills and it will help the students to be more motivated to learn Mathematics thereby it improves retention, and understanding of mathematical concepts

Parents. This study provides parents with important insights into the benefits of game-based learning strategies in mathematics education. Equipped with this knowledge, they can support their child/children by providing access to game-based learning tools at home. Through supportive and interactive reinforcement of mathematical concepts outside of school hours, this involvement can supplement classroom learning.

Curriculum Developers. Curriculum developers are essential in forming instructional strategies and materials. The results of this study can help curriculum designers create and modify instructional materials and curricula so that game-based learning strategies are successfully incorporated. Developers can offer educators and students innovative tools and programs that improve engagement, deepen learning outcomes, and foster a dynamic learning experience in mathematics education by incorporating game-based learning into educational frameworks.

Other Researchers. The result of this study will serve as their guide and help them to collect new ideas and information regarding the strategies and methods that will address the students' learning styles and abilities.

Theoretical Background

Theoretical Framework

Game based learning is considered to be linked to two key educational theories—constructivist and cognitive theories. Learning through games is described as one of the most effective ways to learn as games can improve upon: content mastery, social skills, and higher-ordered thinking skills (Karadag, 2015 as cited in). Moreover, some researchers (Biffi et al., 2016) believe that game-based learning can improve upon constructivist skills such as: students' co-constructing new knowledge, student(s) actively engaging in their own learning process, and student(s)/learner(s) moving away from being novice(s) to becoming expert(s) in concept(s) understanding. With these the following Three theories (Piaget and Lev Vygotsky) are relevant in this study.

This study anchored on the Constructivist learning theory (Lev Vygotsky) Vygotsky highlighted the importance of social interaction in the development of thinking abilities, particularly through the concept

of the Zone of Proximal Development (ZPD), where learners progress with assistance from individuals who have more knowledge. Furthermore, that every human being has a zone of proximal development (ZPD). This is a limit to what one can learn alone on his/ her own. After that, in order for someone to advance in knowledge and skill, they require significant others (Longjohn and Osila, 2022). Game-based learning environments promote collaboration, competition, and communication among peers, effectively using social interaction to support learning. Moreover, Vygotsky's idea of interactive, constructivist learning is consistent with the active participation required in games, where players need to make choices, solve challenges, and use concepts in interactive situations. Furthermore, games encourage intrinsic motivation by providing immediate feedback, rewards, and challenging tasks, which in turn leads to increased engagement and persistence in learning activities. This aligns with Vygotsky's theory that learning in authentic and contextual situations results in greater academic success and a stronger comprehension of the material. Therefore, Vygotsky's ideas about constructivism are very similar to the approach taken in using game-based methods for teaching math. It emphasizes the importance of actively involving students, encouraging social interaction, and utilizing games digital and non-digital games to create meaningful learning opportunities.

Furthermore, Piaget's Constructivism Theory supports this study. Piaget emphasized that through their interactions with their environment, students actively shape their understanding of the world. Piaget believed that children build knowledge through active engagement with their surroundings, continuously adapting and assimilating new information into their mental schemas. By navigating challenges within the game, students not only assimilate mathematical rules and strategies but also accommodate their understanding based on feedback and consequences within the game world. This aligns with Piaget's emphasis on discovery learning, where students construct their own understanding through exploration rather than passive reception of information. Furthermore, game-based learning can be tailored to different stages of cognitive development, offering challenges and complexities appropriate to each student's level of understanding. Therefore, integrating game-based learning in mathematics classrooms not only enhances engagement and motivation but also promotes deeper conceptual understanding and application of mathematical principles, aligning with Piaget's constructivist principles of active learning and knowledge construction."

Another theory that supports the study is the Experiential Learning Theory of Kolbs, which highlights a cycle of learning through active experimentation, abstract conceptualization, reflective observation, and concrete experience. This method involves using interactive educational games as the first tangible experience where students interact with mathematical concepts. Students consider the effects of their choices and actions within the game environment as they play, reflecting on their experiences. By making a connection between their experiences and more general mathematical ideas, this thoughtful observation encourages them to formulate abstract theories and principles that underlie the game. Students then use these newly acquired knowledge in various game scenarios to actively experiment with it, thereby strengthening their learning through practical application. Students develop their critical thinking and problem-solving skills in a contextualized and engaging way as they iterate through this cycle of experiential learning, which also helps them understand mathematical concepts more deeply. Therefore, incorporating game-based learning into mathematics instruction in line with Kolb's experiential learning cycle can significantly improve student learning outcomes and engagement.

Lastly, the social learning theory developed by Albert Bandura emphasizes the value of learning via modeling, imitation, and observation. A lot of game-based learning involves components that call for

social interaction, competitiveness, and teamwork. Game sessions in the classroom, for instance, encourage students to watch their peers, share strategies, and grow from each other's mistakes and successes. This social component of Game based learning can improve students' comprehension and memory of material, which will improve their academic performance. This strategy is also founded in constructivist learning which emphasizes the importance of experiential learning through social interactions with the environment and their peers (Hourdequin et al., 2017). Akcaoglu (2016) suggested game-based learning is that students are learning by design, which is a constructivist approach that views knowing as being situated in action and codetermined by the individual's environment. Students have opportunities to construct their learning by playing games in a learning environment with a series of in-game feedback, tasks that scale with their expected learning goals by completing increasingly challenging activities accompanied with instructionally designed scaffolding such as lectures, group discussions, individual check-ins, or feedback sessions. Students constructing their own learning in collaboration with others is a tenet of learning theory. In this case of game-based learning, a game can be considered the social peer for the learning activity. Moreover, Through game-based learning, students can exchange information and ideas with each other, and collaboratively perform simple tasks and solve challenges. Furthermore, Boctor (2013) pointed out that game-based learning converts teachers into participants in and teachers of the learning process; this contrasts with the traditional method of imparting a repository of information to passive students who may often be uninterested and inattentive.

Conceptual Framework

The main purpose of this research is to find out the effects of game-based learning strategy on students' academic achievement in learning mathematics.

The conceptual framework of the study is presented below. This is the flow of the work to yield answers to the research questions.

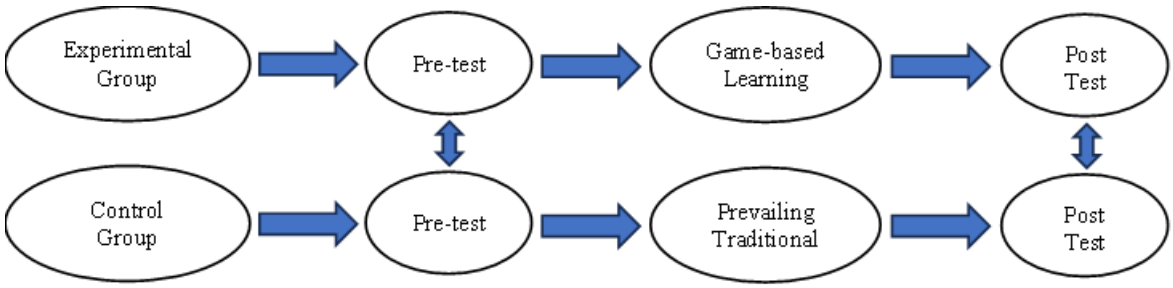

Figure 1. Schematic Diagram showing the relationship between the Independent and Dependent Variables of the study

Figure 1, presents the conceptual paradigm of the study evaluating the effectiveness of game-based learning versus traditional learning methods. The study involves two groups: an experimental group and a control group. Both groups first undergo a pre-test to assess their initial knowledge or skill levels. The experimental group then receives instruction through game-based learning methods, while the control group is taught using prevailing traditional methods. Following their respective instructional interventions, both groups take a post-test to measure any changes in their knowledge or skills. The framework allows for the comparison of pre-test and post-test results within each group to determine the impact of the instructional methods. Additionally, by comparing the post-test results between the experimental and

control groups, the study aims to assess the relative effectiveness of game-based learning compared to traditional instructional approaches. This comparative analysis provides insights into the potential benefits of integrating game-based elements into educational practices.

Literature Review

Mathematics educators motivate students to engage in the teaching-learning process. It is observed that when the students had the focus during the discussion of mathematical concept, their scores in the test were high. However, getting the attention and engagement of the majority of the students during the discussions was difficult. It needs an activity that will catch their interest. According to, (Glavaš & Staščik, 2017). Increasing learning interest in mathematics can be accomplished in several ways, one of which is to integrate the teaching of mathematics with educational games.

Game-based learning (GBL) is one of the modern trends in education in the 21st century. According to Khairuddin and Mailok (2019), the GBL approach is used to stimulate and motivate the students to participate more actively in the learning process, to make the learning process more enjoyable, and to assist the students in comprehending the lessons more effectively. Moreover, according to (Suguitan and Natividad, 2022) Game-based learning is an active learning strategy that employs games to improve student learning.

Numerous research studies have been carried out to investigate the influence of game-based learning strategy on the students' academic attainment and in improving the performance of the learners in Mathematics. And many studies have shown the importance of Game Based Learning in improving the performance of the learners in Mathematics. Hui, H. B., & Mahmud, M. S. (2023). Found out that Game based learning has positively impacted students when they are learning mathematics. It is comprised of two types of cognitive domain (knowledge and mathematical skills) and five types of affective domain (achievement, attitude, motivation, interest, and engagement). Thus, the researchers recommend to o implement game-based learning in the classroom.

Ramirez, & Mercado (2023) conducted a study and determined the effects of games on the mathematics achievement of Grade VII students of Hinangutdan National High School. They 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. 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. 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.

Based on the study conducted by Asanre et. al (2021) who investigated the effect of Mathematics game strategy on senior secondary school students learning outcomes (academic achievement and interest). There is a significant main effect of Mathematics game strategy on the academic achievement and interest of senior secondary school students. Also, it was shown that there is no significant interaction effect of treatment and gender on the achievement and interest of senior secondary school students in Mathematics. The findings further reveal no significant main effect of gender on both academic achievement and interest of senior secondary school offering Mathematics. It was recommended that senior secondary school

teachers should inculcate the use of Mathematics game strategy in the teaching and learning process of Mathematics.

Rondına, J. Q., & Roble, D. B. (2019). The study was a quasi – experimental research conducted to investigate the effect of game-based design activities on students' achievement scores in Algebra. The participants of the study were the two sections of the junior high school students at Misamis Oriental General Comprehensive High School, Cagayan de Oro City, Philippines. One section was assigned as control group who was exposed to traditional approach with usual motivation and varied activities given to them such as board works, seat works, assignments and weekly quiz while the other one was experimental group which was exposed to game activities locally called as "A Line For Win" and "Slide A Picture.Their study revealed that the mathematics game-based design activities demonstrated a positive influence on students learning gains in Algebra. With this, teachers in mathematics may integrate game-based design activities in teaching to make the learners enjoy and arouse their interest in the process of learning and they hope that this way of learning may continue in the future in their upper level mathematics.

Arciosa, R. M. (2021). Conducted also a quasi -experimental research to determine if the use of interactive game-based mathematics lessons improved the pupil's mathematics performance in the classroom of Don Cristito C. Tirambulo Memorial Elementary School, Mabinay District II in Paniabonan, Mabinay, Negros Oriental, Philippines. Results show pupils show interest to learn math because of the features of the game such as color and graphics, sounds and time element that makes it more engaging and fun. The performance of the pupils in mathematics was higher when game-based math lessons were introduced. Game-based math lessons which is perceived by pupils as engaging, exciting and full of fun erases their perception of mathematics as a difficult subject. It is recommended that game-based math lesson be formally part of the Department of Education curriculum and trainings and seminars be conducted to orient the teachers in this classroom intervention for prompt implementation.

Taclay, R. (2013) studied how games affected students' performance in geometry. It was carried out in a public high school in the Philippine Division of Nueva Vizcaya. The study employed a quasi-experimental design, specifically utilizing the pretest-posttest control group design. The study involved two intact groups of fourth-year students, each consisting of 39 students, as the study subjects. The first group which is the control group using the conventional teaching method was assigned, and a second group was designated as the experimental group using the mathematical games strategy. According to the study, pupils who were taught mathematical game strategy scored higher on achievement tests than those who were taught using the conventional approach. In order to attain higher grades in geometry, the researcher advises using mathematical game strategy when presenting and discussing the lessons. Similar findings were reported by Furia et al. (2022) developed a game called KWATRO that revolves around a mathematical card game about gaining mastery with addition of integers in math. In their study, they used Quasi-experimental and One Group Pre-test-post-test research design focusing on determining the effectiveness of KWATRO as a mathematical game in improving the performance of students in addition of integers. The study concluded that the use of the game KWATRO significantly increased the performance level of Grade 7 students and is effective in improving the performance of the least performing students in Mathematics. Furthermore, Naik (2017) studied the use of non-digital games to instruct first-year BSc Computer Science students who lacked experience of formal mathematical instruction beyond elementary levels. Naik reported improved examination results and positive student feedback concerning the learning experience.

Yusof, N. A. M., & Shahrill, M. (2021). Tried to investigate the effectiveness of a non-digital game-based learning approach by assessing the differences in students' achievement score between the pre-test and the post-test on the topic of multiplication and division with indices. A paired sample t-test was used to investigate a significant difference in the students' achievements after implementing the non-digital game-based learning intervention. A total of 35 students from two classes of nine grade students in one of the secondary schools in Brunei Darussalam was involved in the study. Another aim of this study was to investigate the students' perspectives on using a non-digital game-based learning approach in their learning process. This was analyzed through the questionnaire and interviews. The results showed that the integration of a non-digital game-based learning approach in the mathematics lesson did have a positive effect on the students' achievement scores. More than half of the students believed that the game has helped them to improve their Mathematical skills.

Moreover, Turgut and Temur (2017) and Setiawan and Phillipson (2019) conducted meta-analyses and investigate the effects of Game Base learning on students' academic achievements in Mathematics. According to Turgut and Temur's (2017) the use of games in mathematics instruction generally had a positive impact on students' academic achievements. Meanwhile, Setiawan, H., and Phillipson, S.D. (2019) wherein he compiles the findings of the 38 experimental research carried out between 2000 and 2018 investigating the impact of game-based learning method on students' academic achievement. The research findings suggest that there may be a wide-ranging effect indicated by the Hedges g value, which was estimated to be 1.695 for the overall effect size of game-based learning on student achievement. Additionally, the results of the analyses showed that there is no difference in the impact of game-based learning on students' academic achievement based on the sub-dimensions of schooling levels or disciplines.

Digital and online video games are also popular nowadays and it also revealed significant improvement on students learning gains not only in mathematics but also for other disciplines. Pathiratne (2015) conducted a study on instigating and evaluation of an online game as mathematics learning support tool for elementary and middle school mathematics and the results designated that the students' opinion about the game was positive, and suggest that with some extensions the game could be utilized as an efficacious learning implement. Katmada, Mavridis & Tsiatsos (2014) presented the design and development of the prototype of a configurable online 2D game, aimed at assisting the educator in the teaching of primary and secondary school Mathematics. Furthermore, the prototype was evaluated through a pilot study and a long-term intervention in real school settings, in order to assess its usability aspects and to find any possible flaws. According to the results of the two evaluation studies, the students' opinions about the game were mostly positive, and they considered it to be a useful and engaging learning tool, regardless of age and gender. Furthermore, concerning the game's usability, most of its features elicited average to positive responses from the students and the educators alike. Moreover, the educators encountered no difficulties in configuring the game, and the planned educational activities were concluded successfully. Thus, it was deduced that the particular game could actually be successfully incorporated and used by educators as a supplementary tool for the teaching of formal curricular material. Drigas & Pappas (2015) examined the most representative studies over the last decade, which investigated the contribution of video games or educational video games in mathematics education. Video game-based learning seems to have positive effect on students' mathematical skills, as well on students' cognitive and mental skills. At the same time, educational math video games could motivate students towards the course of mathematics. As revealed by surveys, video games could constitute useful auxiliary learning tools, in order to build an

innovative teaching model. Furthermore, Orbon (2022), he proved that using smartphones or video games helps and improves mathematics learning outcomes.

The findings of the study of Abion et. al (2023) highlight the importance of game-based learning in teaching and instruction. The study found that the enjoyment of e-learning games had a positive significant relationship with the learning behavior of grade 6 students in mathematics. Specifically, the study showed that various aspects of enjoyment in e-learning games, such as concentration, goal clarity, feedback, challenge, autonomy, immersion, social interaction, and knowledge improvement, were all positively correlated with the students' interest, confidence, motivation, and perceived usefulness of learning mathematics. The study also suggests that incorporating game-based learning can be an effective teaching tool to enhance and improve students' learning behaviors in mathematics.

In summary, the extensive body of research supports the effectiveness of game-based learning in mathematics education and showed the positive influence of mathematics game-based design activities in the academic achievement of students. Incorporating games, whether digital or non-digital, can significantly enhance students' engagement, motivation, and academic performance. Game-based learning provides a dynamic and enjoyable learning environment that fosters better understanding and retention of mathematical concepts. Therefore, integrating game-based learning into the mathematics curriculum is highly recommended to achieve better educational outcomes.

METHOD

This chapter presents the methodology applied in the conduct of this study and the discussion of the research design; research site and participants, research population, sample size and sampling methods, research instrument, data gathering procedure, data analysis and ethical considerations

Research Design

The research study adopted a quasi-experimental design with control group (pre-test and post-test) to investigate the effects of game-based learning strategy in the academic achievement of students in mathematics. The reason for the adoption of this design is hinged on the fact that intact classes were randomly assigned to experimental and control groups respectively, since it was not possible to have complete randomization of subjects (Nworgu, 2015). Two intact classes were used – one for the control group and another one for the experimental group. The experimental group was exposed to game-based learning strategy while the control used the traditional teaching. Both groups are assessed before (pretest) and after (posttest) a treatment is introduced to the experimental group.

Study Site and Participants

University of La Salette High School Department is the only private catholic school in Santiago City and also the only school in the region accredited by PAASCU (Philippine Accrediting Association of Schools, Colleges and Universities). The school is located at Malvar, Santiago City. The school is also known to be a constant producer of champions and an institution that offers quality catholic education.

The participants are from the two intact classes of Grade 8 students of the University of La Salette Inc. High school.

Population, Sample Size and Sampling Methods

The participants of the study are from the Grade 8 students of University of La Salette Incorporated High

School. The participants of the study were from the two intact classes of Grade 8 of University of La Salette inc. High School S.Y 2023-2024. Currently, there are seven sections of Grade 8, the researchers chose the last two sections of the said Grade level. The assignment to a strategy was done by tossing a coin. G8 St. Jude was labeled as tail and G8 St. John as head. The predominantly occurring side in a rule of 5 was assigned to the control group. Hence, the G8 St. Jude students were assigned to peer learning while the G8. St. John students to conventional teaching. The control group consists of 38 students while the experimental group involved 41 students as the research samples by purposive sampling technique. The subjects were not aware that the experiment is taking place to make the classroom activities be as normal or possible, thus eliminating the effect of some extra factors that would affect the result of the experiment.

Research Instruments

The Achievement Test. The main source of data was the 50-items researchers- made Mathematics Achievement Test, all multiple-choice questions having four options with one correct answer. Items of this test was constructed based on the 4th Quarter Lessons of Grade 8 as indicated in the DepEd Curriculum Guide. The researchers also prepared a Table of Specification (TOS) to ensure a balanced distribution of the items. 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. The first draft of the test underwent the content validation by the experts in mathematics. Three Mathematics Experts were tapped for content validation. Corrections and suggestions were integrated before the second draft of the test was tried out to 30 students of Grade 8 from other sections which are not part of the experiments. The results were used to determine validity and reliability indices of the test. Kuder-Richardson (KR-20) was used to compute the internal consistency (reliability) of the instrument. The reliability coefficient result was 0.9141 which implies that the Achievement Test is highly reliable to test the needed mathematical skills.

The Mathematical Games. The researchers prepared the different games for the experimental treatment like Probability Trio: A Three-Game Challenge, Case Quest: The Million Peso Challenge derived from deal or no deal gameshow, Card Category Conundrum,a card game activity and more activities. The objectives of the mathematical games are aligned in the objectives of each lesson. Mathematical games are teacher- made games (playground and class
room games).

Data Gathering Procedure

To achieve the desired goal of the study, the researcher prepared the research instruments to be validated. Upon the finalization of the instrument, the researcher formally wrote a letter requesting permission from the principal to conduct the study. During the first week, the pretest was administered in the experimental and control groups. After the pretest, the treatment started. The schedules for the experimental group and for the control group were their usual Mathematics class schedules. Lesson plan was developed by the researcher for experimental group using game-based activities and control group using lecture method for the period of four weeks. The lesson plans were made by the teacher and checked by the mathematics department head. The same lesson plans were used for the two groups. During the treatment period, the experimental groups were taught using game based instructional technique on the other hand, the control group was also given a series of lessons on the same topic but without the mathematical games. The teacher

discussed the concepts and after the discussion a series of activities such as seat works, board works and assignments were given to the control group while games such as Probability Trio: A Three-Game Challenge, Case Quest: The Million Peso Challenge derived from deal or no deal gameshow, Card Category Conundrum, a card game activity and more activities were teacher made game activities were conducted in the experimental group.

At the conclusion of the four weeks, after all the topics to be covered, post-test was given to both the control and the experimental group to assess the learning of the students and to measure and assess the effectiveness of game-based learning strategy. The Post-test was just similar to the pretest. treatment groups. However, in these post-tests the items of the Math Achievement test were re-arranged/reshuffled to avoid familiarity with the items of the instrument by the students. The result of the posttest was recorded and compared with the results of the pretest to see if there is an increase in the scores of the students to determine the effect of the intervention in the achievement of the students in Mathematics.

Data Analysis

After the administration of the instruments, the researcher recorded the results and use the following statistical tools:

1. Mean and Standard Deviation was used to determine the pretest and post-test mean scores of the students both control and experimental as well as to determine the variability of scores from the mean.
2. Paired samples t-test to determine whether there is a significant difference between pre-test and post-test scores within each group. Students' t-tests (95% confidence level) were used to analyze the differences in the pretest scores between the control group and the experimental group.
3. Independent t-test t 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.
4. Cohens D. was used to calculate the effect size of the game-based learning strategy on the academic achievement of the participants.

Ethical Considerations

The researcher followed ethical protocol by requesting consent from the school administration. Given the context of the research being an educational intervention within regular classroom activities, parental consent was not sought but the researchers comply with school guidelines and also ensured confidentiality, the individual results of the assessments remained confidential and use only the information to answer the research questions. The intervention used in the study was designed to enhance learning outcomes and posed no physical, psychological, or emotional harm to the students. Transparency and honesty were maintained throughout the research process, with findings reported accurately and without data manipulation. The researchers aimed to conduct the research in a manner that respected the rights and well-being of all participants involve, no biases involved.

RESULTS AND DISCUSSION

Part 1. Pre-test and Post-test Scores of the Participants

Table 1. Descriptive statistics of Pre-test and Post-test Scores of the two groups

		Pre-Test		Post-test		
	N	Mean	SD	Mean	SD	MD
Control	38	15.1	3.70	18.1	4.19	3
Experimental	41	14.2	4.33	21.3	5.72	7.1

Note: N = Sample Size, M = Mean, SD = Standard Deviation, MD = Mean Difference

The data in **Table 1** provides a detailed comparison of the outcomes observed between the experimental group, where students underwent game-based learning, and the control group, which used the traditional talk and chalk method. As shown in the table students exposed to game-based learning strategy had mean mathematics test score of (M = 14.2, SD = 4.33) at the pretest and (M = 21.3, SD = 5.72) at the posttest, while the students exposed to talk and chalk method had mean mathematics test score of (M = 15.1, SD = 3.70) at the pretest and (M = 18.1, SD =4.19) at the posttest. Mean gain scores of 7.1 and 3 for the experimental and control groups respectively indicate that students exposed to game-based learning strategy had higher posttest mean mathematics test score than their control group counterparts. To find out if the difference in means was statistically significant, the corresponding hypothesis was therefore tested (Table 2-5).

The study conducted by (Rondina and Roble 2019) and (Turgut & Dogan Temur, 2017) supports the finding of this study that students who were exposed to mathematical game activities had a better achievement score than the students who were exposed to the traditional method of teaching. The result can be attributed to the integration of game activities in teaching mathematics which found to have positive effect on the student achievement.

Hypothesis Testing before T-test, a homogeneity test was employed to test whether or not the research samples have homogenous variance and a normality test was also conducted to test the distribution of the population. The Levene homogeneity test result was the p-value is .649127. The result is not significant at $p < .05$. which shows that the samples are homogenous, while the Shapiro wilk test result was he p-value is .275 The result is not significant at $p < .05$ indicates a normally distributed population.

Ho1: There is no significant difference in the pre-test scores of the experimental and control group in the achievement test of Mathematics

Part 2. Difference between the scores of the participants under control and experimental group

2.1. Pre-Test Scores

Table 2. Independent Samples T-Test for control and experimental group Pre-test

	N	Mean	SD	Statistic	Df	P	Interpretation	Decision
Control	38	15.1	3.70	0.947	77.0	0.347	Not significant	Accept H_0
Experimental	41	14.2	4.33					

Note. H_a $\mu_{Control} \neq \mu_{Experimental}$

Table 2 shows the significant difference between the scores of the participants under control and experimental group in terms of their pre-test.

Table 2 reveals the result of the comparison of the pre-test scores of the learners exposed to game-based learning strategy and to traditional teaching. In the control group, the mean score and standard deviation were calculated as (M =15.1, SD = 3.70), whereas for the experimental group, the values were recorded as (M = 14.2, SD = 4.33). Moreover, it could be gleaned from the table that no significant difference exists in the pre-test scores of the two groups of learners. The computed p-value of 0.347 is greater than the 0.05 level of significance. Based on this evidence, Ho1 is accepted which implies that the difference between the two groups was insignificant, and the experimental and the control groups were equivalent before the treatment. This is because the students came from the same class.

This outcome is analogous to the results of the studies of Ramirez and Mercado (2023) 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.

2.2 Post-Test

Table 3. Independent Samples T-Test for control and experimental group

Group	N	Mean	SD	Statistic	Df	p	Interpretation	Decision
Control	38	18.1	4.19	-2.83	77	<.008	Significant	Reject H_o
Experimental	41	21.3	5.72					

Note. H_a μ Control ≠ μ Experimental

Table 3 shows the significant difference between the scores of the participants under control and experimental group in terms of post-test.

Table 3 displays results of an independent-samples t-test that was applied to compare the overall mean score of experimental and control group with respect to posttest. In the control group, the mean score and standard deviation were recorded as (M = 18.1, SD = 4.19), while the corresponding figures for the control group were (M = 21.3, SD = 5.72). Table 3 shows that there exists a significant difference between the post test scores of the students in each group since the computed p-value was 0.008, which is lower than the level of significance which is .05. Hence, Ho2 is rejected. This outcome revealed that there is a significance difference in their academic achievement. This outcome underscores that a substantial difference indeed existed in the achievement of students who were exposed to game base learning strategy in comparison to their counterparts taught through the talk and chalk method. In simpler terms, the experimental group, displayed significantly superior performance compared to the control group.

This result is similar to those of (Ramirez& Mercado 2023; Asanre, et. al. 2021; Rondina and Roble 2019; and, Ezeugwu et al. 2016) 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)

Part 3. Difference between the pretest and posttest mean scores under control and experimental group

3.1 Pre-test and Post-test of Control Group

Table 4. Paired sample t-test for control group with respect to pretest and posttest

Group	N	Mean	SD	Statistic	Df	P	Interpretation	Decision
Pre-test	38	15.1	3.70	-3.52	37	0.001	Significant	Reject H_o
Post-test		18.1	4.19					
Cohens d = .571 : medium to large effect								

Note. H_a $\mu_{\text{Measure 1 - Measure 2}} \neq 0$

Table 4 shows the significant difference between the scores of the participants under control and experimental group in terms of their pre-test

In order to assess the first hypothesis a paired-samples t-test at significance level of 0.05 was used. The goal was to compare the significant difference between the pretest and the posttest mean scores of the control group. Table 4 revealed that there was a significant difference in the pretest scores of the control group (M=15.1, SD=3.70) and post-test scores (M=18.1, SD=4.19) of the control group. Since, the absolute value of the calculated t-statistic (-3.52) is greater than the critical t-value (2.02619) and the p-value (0.001) is less than 0.05, hence, Ho3 is rejected. These results revealed that there is an increase in the academic achievement of students. However, in addition to the finding above, Cohen's d was also computed to determine the magnitude of the effect of traditional teaching. The calculated effect size was .571 which is considered as medium to large effect size. This implies that while it's true that there is a significant difference between the pre-test and post-test scores of the participants, the Cohen's d suggests that traditional method has a medium to large impact on students' achievement. This finding suggests that the teachers need to vary their teaching strategies to achieve better academic achievement.

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 Ramirez and Mercado (2023) 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.

3.2 Pre-test and Post-test of Experimental Group

Table 5. Paired sample t-test for experimental group with respect to pretest and posttest

Group	N	Mean	SD	Statistic	Df	P	Interpretation	Decision
Pre-test	30	14.2	4.33	-8.78	40	<.001	Significant	Reject H_o
Post-test	30	21.3	5.72					
Cohens d = 1.37 : large effect size								

Note. H_a $\mu_{\text{Measure 1 - Measure 2}} \neq 0$

Table 5 uncovers the comparative analysis of the pre-test and post-test results of the learners exposed to

game-based learning strategy. Based from the table, there is a significant difference between the test results pre-test (M=21.1 , SD= 4.33) and posttest (M= 21.3 SD= 5.72) of the students exposed to game based learning strategy. As shown in the result that there is a highly significant difference between the test results (pre-test and post-test) of the learners exposed to game-based learning strategy. This is proven by the p – value of <.001at a 0.05 level of significance. Moreover, test statistics would further confirm that the absolute value of the computed t -statistic which is -8.78 is greater than 2.02107, which rejects the H04 null hypothesis, which states that there is no significant difference in the pre-test and post-test performance of the participants were expose to the game-based learning strategy. This finding implies that game-based learning contributes to the student's success in getting a higher performance. It can also be inferred that students can achieve higher test scores through game-based learning strategy. In addition to the finding above, Cohen's d was also computed to determine the magnitude of the effect of game-based learning strategy. The effect size obtained was d= 1.37 which is considered as a large effect size. It shows that there is a huge difference in the performance of the students in their post-test as compared to their performance in their pre-test. The significant t-test results, along with the large effect size indicated by Cohen's d, suggest a substantial and meaningful difference between the pre-test and post-test mean scores. This provided evidence that the game-based learning strategy had a substantial impact on student achievement in mathematics and effective in producing academic gains in mathematics among student.

This result agrees with some research findings conducted in studying the effectiveness of game-based learning on students' performance. For example, Ramirez& Mercado 2023) and (Rondina and Roble 2019) had found significant improvement in the subjects' achievement after being taught using game-based learning strategy.

Part 4. The Effect Size of the Game-based Learning Strategy on the Academic Achievement of the Participants.

Effect Size	Interpretation
Cohens d= 1.37	Large Effect Size

Table 6 shows the effect size of the Game based Learning Strategy on the Academic Achievement of the Participants in learning Mathematics

As shown in **table 6,** the experimental group yields Cohens d= 1.07 which is considered as large effect. This implies that game-based learning has a large effect on the academic achievement of students in learning Mathematics and Game-based learning is an effective strategy in enhancing the learner's academic achievement in Mathematics.

This finding is similar with the findings of Setiawan and Phillipson (2019) wherein he compiles the findings of the 38 experimental research carried out between 2000 and 2018 investigating the impact of game-based learning method on students' academic achievement. The research findings suggest that there may be a wide-ranging effect indicated by the Hedges g value, which was estimated to be 1.695 which is considered high effect. Other study with similar findings was from the study of Hunt et al. (2023) and Martin (2018) with 1.09 and 1.26 computed Cohens d which can also be interpreted as high effect size. In conclusion, the research indicates that introducing students to game-based learning strategy in mathematics proves to be a beneficial approach for enhancing academic performance and fostering student achievement.

Conclusion

From the findings presented and discussed, the researcher concluded the following:

1. Both the experimental and control groups showed progress from their pretest to posttest scores. However, the experimental group that engaged in game-based learning showed a significantly higher average gain of 7.1, compared to the control group, which used the traditional talk-and-chalk method and had a gain of 3. The greater mean difference seen in the experimental group indicates that game-based learning has a significantly positive impact on students' mathematics performance. This result suggests that learners may achieve improved outcomes when engaged in game-based learning strategies, as opposed to traditional teaching methods.
2. There is no significant difference between the experimental group and the control group in their pretest scores, implying that prior to the intervention the math achievement of the two groups was comparable before the intervention. The posttest results however show a substantial difference between the two groups with the experimental group scoring higher. This result shows that when compared to the control group that used the conventional talk-and-chalk approach the experimental group which used the game-based learning strategy showed noticeably higher academic achievement. Therefore, the findings highlight how well game-based learning can improve students' mathematical performance.
3. The control and experimental groups' mean scores on the pre- and post-tests differ significantly from each other, indicating that both teaching approaches helped students' academic performance. Positive results were obtained by the control group, which continued to benefit from traditional teaching methods. But the group that engaged in game-based learning showed even more improvements, demonstrating how successful this method is. All things considered, while conventional teaching approaches have their merits, integrating game-based learning tactics can produce even greater mathematical results for students.
4. The effect size of game-based learning strategy as measured by Cohens d indicates a large effect.

Recommendation

In the light of the findings, conclusions and implications drawn from the study, the researcher recommends the following:

1. Researchers strongly advocate for mathematics educators to employ game-based activities as this approach can improve their performance, and help them develop confidence in mathematics. In addition, teachers may Combine traditional teaching methods with game-based learning to cater the different learning styles and paces of every student. However, optimize the effects of game-based learning on student performance, devote more instructional time to these activities.
2. The mathematics educators need to revisit and update the activities every quarter or before the start of the quarter for possible enhancements not only the technique but the performances of the students in the mathematics subject. Educators and students may try to use the game-based activities
3. The findings revealed that game-based learning promotes academic performance. Hence, Curriculum Developers are encouraged to develop a curriculum that includes structured times for game-based activities alongside traditional lesson into the mathematics curriculum.
4. Institutions and educators should allocate resources towards professional development programs that empower teachers to proficiently use game-based strategies into their instructional methodologies. Seminars, conferences, and workshops should be organized for teachers. This would help improve their knowledge and skills of game-based strategies to achieve effective implementations.

5. Teachers should find more ways to improve students' academic performance through various innovative strategies.
6. Engage parents by educating them about the advantages of game-based learning and offering suggestions or guidance on how they can support their children's learning at home with educational games.
7. Future research should be conducted with larger and more diverse sample sizes to validate the findings of this study. Moreover, since this action research focused only on offline mathematics game-based learning activities, research for the effects of digital games should be explored.

Conflict of Interest

There were no conflicts of interest recorded among the authors and participants of the study.

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