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THE EFFECTS OF GAME-BASED MATHEMATICS LEARNING ON PUPILS' ACADEMIC PERFORMANCE IN JUNIOR HIGH SCHOOL

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Abstract

The purpose of this study was to evaluate the effects of game-based mathematics learning on students' academic performance in Junior High School. The particular goals were to find successful game-based mathematics learning methodologies, investigate their impact on students' attitudes toward mathematics, and compare their efficacy to traditional learning methods. The study used an action research technique with Form 1 students as the focus, and a sample size of 40 students was used, utilising the census method. Pre-test, mid-test, and post-test assessments were used to measure the impact of game-based mathematics learning. The performance of the students was calculated, and the mean score was used to compare their performance before and after the intervention. The daily attitude survey instruments were used to measure students' attitudes toward mathematics. SPSS version 25.0 was used to analyse quantitative data, which included descriptive and inferential statistical methods. Certain games, such as number munchers, fraction action games, and emojilicious coordinate story games, were found to be useful in increasing kids' mathematical proficiency in the study. Furthermore, game-based learning had a clear positive impact on students' attitudes toward mathematics, making it more interesting and engaging for them. Furthermore, the implementation of the game-based learning intervention resulted in a significant improvement in student results on mathematics examinations. According to the study's findings, educators should explore introducing game-based learning activities into their mathematics classes since they have the potential to boost student attitudes and arithmetic achievement, making the subject more interesting and engaging for pupils.

Keywords: *Game, Learning, Academic Performance, Junior High School*

1.1 Background to the Study

In many facets of human existence, including science, technology, engineering, and business, mathematics is a crucial subject. As a result, math education is now a crucial part of academic curricula all around the world (Ojose, 2018). Contrarily, it has been noted that a lot of pupils struggle with the subject of mathematics, which has a negative impact on their academic performance (Hazarika, 2020). This is largely due to a lack of enthusiasm, poor comprehension, and inefficient instructional strategies (Aliakbari & Faraji, 2011). For many years, Ghana's educational research and policy have placed a lot of emphasis on mathematics education. The performance of students has been a subject of concern even though mathematics is acknowledged as being essential to science, technology, engineering, and business (Asamoah & Baah, 2020).

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In mathematics, the vast majority of Ghanaian students perform poorly, which leads to a high failure rate on national exams (Gyamfi, 2017). This poor performance is a result of a variety of factors, including inadequate instructional materials, a lack of qualified mathematics teachers, and ineffective teaching strategies (Asamoah & Baah, 2020).

Math education has used traditional teaching techniques like lectures and textbooks for many years. However, it has been discovered that these methods fall short when it comes to motivating pupils and raising academic accomplishment (Chen et al., 2020). In order to improve students' academic performance and excitement for mathematics, educators have resorted to cutting-edge teaching strategies like game-based learning.

A teaching strategy known as "game-based learning" uses games to engage students and improve learning (Papastergiou, 2009). Because it allows students to study in a fun and engaging setting, game-based mathematics learning has been proven to be an effective technique for teaching mathematics (Egenfeldt-Nielsen et al., 2016). The development of students' problem-solving and critical-thinking abilities can also benefit from game-based mathematics instruction (Egenfeldt-Nielsen et al., 2016). According to Genefeldt-Nielsen et al. (2016), game-based learning has become a successful teaching technique for improving students' mathematics performance and interest. According to Prensky (2013), game-based learning is a method of instruction that makes use of games to impart academic knowledge and abilities. Although there hasn't been much research on the efficacy of this technique in raising students' academic achievement, some instructors in Ghana have used game-based learning to teach mathematics in the classroom.

Despite the potential advantages of game-based mathematics education, it is unknown whether it can improve students' academic performance, especially at Walembelle Junior High School. As a result, the goal of this study is to examine the effects of game-based mathematics learning on students' academic performance at Walembelle Junior High School and to identify the precise game-based mathematics learning approaches that have been shown to have the greatest impact on students' academic performance.

1.2 Statement of the Problem

In order for students to succeed in a variety of academic subjects, mathematics education is a crucial component of the academic curriculum (Erlina & Nurhayati, 2020). However, it has been shown that many students find mathematics to be difficult, which negatively affects their academic achievement (Hazarika, 2020). Students at Walembelle Junior High School have a difficult time learning mathematics, and many of them struggle to get decent scores. The performance of students in mathematics has been improved through a variety of strategies, including conventional teaching techniques like lectures and textbooks. However, it has been discovered that these techniques fall short in terms of motivating students and raising their performance (Chen et al., 2020). By making the subject more exciting and engaging for students, game-based mathematics learning has become a potentially effective method of teaching mathematics (Papastergiou, 2009). This study explores the effects of math learning through games on the academic performance of pupils at Walembelle Junior High School and determines the best methods for doing so. The goal of the study is to find the most effective game-based learning techniques and close a gap in the literature.

1.3 Purpose of the study

This study examines the effects of game-based arithmetic instruction on the academic performance of pupils at Walembelle Junior High School. It attempts to investigate its efficacy and pinpoint the best game-based learning strategies for enhancing mathematical proficiency. The research's conclusions will direct instructional strategies to improve pupils' academic achievement in mathematics.

1.4 Research Objectives

This study's main goal is to simulate how students' mathematics performance at Walembelle Junior High School is affected by game-based learning (GBL).

The precise goals are to:

1. Identify the specific game-based mathematics learning strategies that are most effective in improving pupils' academic performance at Walembelle Junior High School.
2. Determine the influence of game-based mathematics learning on pupils' attitudes towards mathematics in Walembelle Junior High School.
3. Investigate the effectiveness of game-based mathematics learning on the academic performance of pupils as compared to the traditional learning method in Walembelle Junior High School.

1.5 Research Questions

The following research questions guided the study:

1. What are the specific game-based mathematics learning strategies that are most effective in improving pupils' academic performance at Walembelle Junior High School?
2. Does game-based mathematics learning influence pupils' attitudes towards mathematics in Walembelle Junior High School?
3. Is game-based mathematics learning more effective in improving the academic performance of pupils as compared to the traditional learning method?

1.6 Significance of the Study

The importance of this study rests in its ability to help Ghana's junior high schools, specifically, enhance their mathematics curriculum. This study can shed light on the efficacy of game-based learning as a method of instruction in math education. The study's conclusions can guide educational strategies that will improve students' academic performance in mathematics, which is essential to their success in the future. This study can also offer evidence-based support for the inclusion of game-based learning techniques in the Ghanaian junior high school mathematics curricula.

Additionally, this research can advance our understanding of game-based learning and how it affects students' academic performance, which will be useful for researchers, educators, and policymakers in the field of education. Overall, this research has the potential to significantly affect both the academic performance of junior high school students in Ghana and the standard of mathematics instruction.

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2.0 Review of related literature

2.1 Concept of Game-Based Mathematics Learning

A teaching strategy that incorporates elements of games into the teaching and learning of mathematics is known as game-based mathematics learning. This method seeks to involve students in pleasurable, engaging activities that foster conceptual knowledge, problem-solving abilities, and mathematical reasoning. Game-based learning can increase the learning process's engagement, motivation, and effectiveness by combining the natural appeal of games into mathematics teaching. Numerous theoretical frameworks support the idea of game-based mathematics learning. For instance, constructivism emphasizes the creation of knowledge actively and the significance of giving students meaningful situations in which to learn (Jonassen, 1999). Games can operate as these contexts by presenting mathematical ideas and issues in immersive, interactive ways that let students participate and build their comprehension.

Design considerations are essential in creating environments for learning mathematics through games. These principles include adhering to curriculum standards, including mathematical content, balancing difficulty and support, and including procedures for feedback and evaluation. Game-based learning settings that abide by these guidelines can guarantee that mathematical ideas are adequately addressed while maintaining a level of difficulty that encourages engagement and learning (Squire, 2011).

Prensky (2013) asserts that game-based math instruction has demonstrated positive benefits in terms of motivation, engagement, and learning outcomes. According to research, games can increase students' intrinsic motivation for and pleasure of math. For students to experiment, make judgments, and feel the effects of those decisions, they offer a dynamic and safe environment, which fosters critical thinking and problem-solving abilities (Barab et al., 2014).

Additionally, game-based math instruction can help students' procedural fluency, conceptual understanding, and mathematical knowledge. In contrast to traditional training, students who participated in game-based mathematics learning had significantly higher levels of mathematical proficiency, according to a study by Kay and Barab (2016). The study also emphasized how engaging and enjoyable games are for students when learning math.

Learning mathematics through games also stimulates cognitive and metacognitive processes. As students work through mathematical issues, games can help them develop their reasoning, logical thinking, and strategic planning skills (Shute et al., 2015). Additionally, by giving students the chance to keep track of and control their learning progress, games can improve metacognitive awareness (Azevedo & Witherspoon, 2015). Gaming-based mathematics education includes significant amounts of collaboration and social interaction. Multiplayer games and cooperative problem-solving exercises motivate students to cooperate, share ideas, and gain insight from one another's viewpoints (Roschelle & Teasley, 1995). These group activities can help students' communication and mathematics knowledge.

While game-based mathematics learning has many advantages, there are drawbacks as well. Effective game design that adheres to curriculum standards and offers adequate challenges calls for considerable thought (Ke, 2016). Insufficient teacher support for implementation and the assessment of learning outcomes in game-based environments are other issues (Bourgonjon et al., 2013). A potential method that blends the fun of games with the educational objectives of mathematics education is game-based mathematics learning. Students can strengthen their mathematical thinking, problem-solving abilities, and conceptual knowledge in a fun and engaging way by including games in the learning process. Despite its difficulties, game-based mathematics instruction has the potential to improve learning outcomes in terms of engagement and motivation.

2.2 Game-Based Mathematics Learning Strategies

As one of the primary trends in learning for the twenty-first century (Ahmad & Iksan, 2021), game-based learning (GBL) has recently attracted more scholarly attention (Zou, 2020). Using student-centered learning activities, GBL in mathematics education improves learning efficiency by striking a balance between in-class instruction and educational games (Lasut & Bawengan, 2020). Additionally, it is one of the more innovative and enjoyable techniques, and pupils will, inadvertently, pay attention to the teacher's lessons. This is because pupils naturally enjoy playing video games. In addition, educational games might help students develop a love of learning, the confidence to face a variety of challenges along the way, and the patience and focus to get through them (Liu et al., 2021). All of these traits are essential for higher education in the development of lifelong learners.

This tactic is also grounded in constructivist learning, which emphasizes the value of social interactions with peers and the environment for experiential learning (Hourdequin et al., 2017). There is a lot of evidence showing that GBL is popularizing as a successful learning strategy used to develop an engaging learning environment. The success of digital games in the educational setting has further demonstrated the potential of GBL in enhancing motivation, engagement, and social influences on the basis of empirical evidence from recent studies (Hernández-Lara and Serradell-Lopez, 2018).

Digital and non-digital games are the two categories of games, according to Wong and Osman (2018). The goal of GBL, whether it takes the shape of digital or analog games, is to meet the established learning objectives. The GBL technique is utilized, in accordance with Khairuddin and Mailok (2019), to encourage and motivate students to engage more fully in the learning process, to make learning more fun, and to help the students better understand the courses. With the help of the GBL technique, teachers may include active learning in their lessons, boost student interest and engagement, and get immediate feedback on their performance. Khairuddin and Mailok (2019) identified the following game-based mathematics learning strategies as some of the most successful ones for enticing junior high school pupils and fostering the development of their mathematical abilities: arithmetic Games and Puzzles: In order to make learning more engaging and interactive, this technique adds arithmetic games and puzzles into the curriculum. Board games, card games, online math games, and logic puzzles that call for mathematical reasoning and problem-solving abilities can all fall under this category (Khairuddin & Mailok, 2019). The use of gamified learning platforms or educational apps that provide math-related challenges, incentives, and progression systems is part of this technique (Khairuddin & Mailok, 2019). These platforms frequently allow students to track

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their progress and offer individualized learning experiences, which encourages them to develop their skills (McCausland & Villiers, 2019).

Math Competitions and Challenges: As part of this technique, the classroom or school may host math contests or challenges. These activities can promote constructive rivalry, cooperation, and critical thinking. To solve arithmetic problems in the allotted time, students can work alone or in groups. Simulated real-world situations in which students can use their mathematics knowledge and abilities are the focus of this technique. Students can use math calculations to operate a virtual store, plan a trip, or budget their costs, for instance. This method aids students in understanding how arithmetic is used in real-world situations. Math-based Board Games: This tactic entails incorporating math ideas into common board games or creating board games that focus specifically on arithmetic. For instance, by playing a math-based version of chess, students can practice addition and subtraction while developing their strategic thinking abilities.

Interactive Resources Online: Using interactive online resources like virtual manipulatives, interactive graphs, and math simulations is the focus of this technique (Khairuddin & Mailok, 2019). With the use of these materials, students can experiment with various scenarios and visualize mathematical concepts, which improves their comprehension and problem-solving skills (Khairuddin & Mailok, 2019).

Collaborative Problem-Solving: This approach promotes cooperative problem-solving exercises where students tackle arithmetic problems in pairs or small groups. This strategy encourages collaboration, dialogue, and the exchange of various problem-solving techniques. Video Games with a Math Theme: This tactic introduces video games with a math theme. These interactive learning experiences frequently include math problems, riddles, and quests that demand deductive reasoning and numerical computations. Projects in Math: This approach assigns projects in math that incorporate practical applications of mathematical ideas. For instance, kids can create a house's blueprint, analyze sports data, or conduct surveys and apply math to evaluate the results. This practical approach encourages critical thinking and innovation.

Math-Based Escape Rooms: Using this technique, math-based escape rooms are created, requiring students to answer math problems in order to advance and finally "escape" the chamber. This engaging exercise encourages tenacity, logical thinking, and problem-solving (McCausland & Villiers, 2019). It is advised that when putting game-based techniques into practice, it is crucial to make sure that they are in line with the objectives of the curriculum and that they offer worthwhile learning opportunities. The games should be hard while also entertaining to help students get a deeper comprehension of mathematical ideas and abilities.

2.3 Specific Game-Based Mathematics Learning Strategies that Improve Pupils' Performance

Due to its potential to allow active learning experiences and foster student involvement in the classroom, game-based mathematics education has grown in popularity (Wayand, 2016). According to studies, using games to teach math is particularly beneficial since it improves students' problem-solving abilities, intrinsic motivation, and mathematical performance (Wayand, 2016). According to recent studies, there are a number of distinct game-based tactics that can be employed to raise students' performance in the area of mathematics learning (Wayand, 2016).

The usage of computer-based games is one of the most frequently researched game-based ways to enhance students' academic achievement. Computer games have been shown in studies to boost student motivation and engagement in mathematics learning (Sharat & Montague, 2018). Additionally, it has been demonstrated that computer games can improve students' academic performance in mathematics, particularly when they are taught problem-solving techniques through activities that are related to games (Fang & Chong, 2016). Additionally, by stimulating a variety of cognitive functions and giving students a relevant environment for mathematical learning, computer-based games can be used to help students develop a deeper comprehension of mathematical topics (Fang & Chong, 2016).

Peer games are another game-based mathematics method that has been shown to be very successful in raising students' academic achievement. Cooperative peer games have been shown in studies to enhance mathematical performance in a number of ways (Muller et al., 2019). For instance, cooperative peer games give students a chance to hone their communication and teamwork abilities, which they can subsequently apply to solve mathematics problems (Muller et al., 2019). Additionally, cooperative peer games can help students develop their mathematical reasoning and facilitate better communication among team members (Muller et al., 2019). Math learning has also been proven to benefit from game-based tactics that incorporate the use of tangible manipulatives (McCausland & Villiers, 2019). Physical manipulatives give pupils a more tactile learning experience when learning mathematics and can enhance their performance (McCausland & Villiers, 2019). According to studies (McCausland & Villiers, 2019), using tangible manipulatives can assist kids in having a positive mindset toward learning mathematics.

2.4 Influence of Game-Based Mathematics learning on Pupils' Attitudes toward Mathematics

More recently, the potential of computer games for arithmetic learning has been investigated in the context of education. Numerous studies have shown that using game-based mathematics learning can affect students' attitudes about the subject. According to studies, learning mathematics through games can improve students' attitudes about the subject. According to Liu et al. (2021), educational games encourage students to love learning, feel comfortable addressing a range of problems along the road, and successfully conquer these obstacles with patience, focus, and self-assurance. Students grow interested in the subject and adopt a favorable attitude because of this. People's reactions to playing video games can be both favorable and unpleasant. Ghasemzadeh et al. (2015) conducted a study to examine the impact of game-based learning specifically on attitudes toward mathematics. They discovered that participants who had learned mathematics in a game-based environment displayed a more positive attitude toward mathematics, as measured by their self-reported statements.

In a study published in 2017, Zahraei and Aliakbari compared students' views toward mathematics before and after they participated in a game-based learning environment. According to their research, pupils who participated in the game-based learning environment demonstrated a considerably better level of enjoyment

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for mathematics and a more upbeat mood than those who did not. Pring et al. (2018) conducted a systematic review based on their prior research to investigate the impact of game-based learning on students' attitudes toward mathematics. 11 research were included in the study, 8 of which concluded that game-based learning improved students' attitudes toward arithmetic, whereas the remaining 3 either found no change or even a decline in such sentiments. They concluded that game-based learning might improve students' attitudes toward mathematics.

Yldz (2020) investigated the effect that digital game-based learning has on students’ attitudes toward mathematics in research. In the 13 empirical investigations that were part of the review, attitudes toward mathematics among students were found to have changed significantly in 10 of them, significantly less in 1, and not at all in 2, according to the findings of the other two research. According to Yldz (2020), game-based learning improves student attitudes by encouraging attention, engagement, and enjoyment. In a similar vein, studies by Smith (2009) and Ferguson (2012) discovered a correlation between improved attitudes toward mathematics and the usage of game-based mathematics learning in the classroom.

In research by Smith (2009), students were split into two groups; one group was placed in a classroom with traditional teaching methods, and the other was allocated to a game-based mathematics-learning environment. The Attitude Toward Mathematics Scale was used to gauge the participants' attitudes toward math at the start and end of the study. When compared to the control group, it was discovered that the group that learned mathematics through games showed a statistically significant improvement in attitude. Similar to this, in a research by Ferguson (2012), pupils were divided into two groups: those receiving traditional mathematics training, and those receiving game-based mathematics instruction. The study discovered that during the course of the study, the students who got game-based mathematics instruction displayed a better attitude toward mathematics. The study also discovered that pupils who were exposed to a game-based environment showed better levels of involvement than those who were exposed to a traditional environment.

The discussion above suggests, in general, that there is enough evidence to imply that game-based mathematics instruction can positively affect students' attitudes toward mathematics. The best approaches to integrate game-based mathematics instruction into the classroom will require further investigation into various teaching strategies.

2.5 Effectiveness of Game-Based Mathematics Learning on the Academic Performance of Pupils as Compared to the Traditional Learning Method

Recent research has examined the impact of game-based mathematics training on students' academic achievement in comparison to traditional instruction. In order to engage students, serious games must appeal to their innate motivations for competition, social connection, and creativity (Burguillo, 2010). Children are naturally social creatures that learn best via inquiry and contact with others, according to Vygotsky (1978). Since serious games allow students the chance to examine ideas through the form of competitive exploration, GBL in mathematics is based on this idea of social interaction. According to earlier research (Burguillo, 2010; Cagiltay, Ozcelik, & Ozcelik, (2015)), competitive learning of mathematics through games promotes motivation and cooperation and ultimately learning results as compared to the traditional approach of learning.

Kebritchi et al. (2010) investigated the impacts of implementing significant GBL in the pre-algebra math classroom. The classroom teachers in this study believed that the use of serious gaming was successful because the games were immersive in nature, provided a fresh perspective on how to present and experience learning, provided the students with context and inspiration to work on the current mathematical concepts, and made math enjoyable. Vandercruysse, van Paassen, and van Merrinboer (2019), who discovered that pupils who were taught mathematics using a game-based method outperformed those who were given traditional education on achievement assessments, observed similar results in a study of 7th-grade children. Talib and Rizvi's (2018) research looked at the effectiveness of game-based math instruction for Malaysian secondary school pupils. The study's findings demonstrated that arithmetic students who received game-based learning fared higher on achievement assessments than those who received solely traditional training. The study also discovered that game-based learning boosted problem-solving abilities and increased student engagement.

Hosseinifard, Pourghafarin, Salehi, and Ahmadi (2019) discovered that pupils who learned mathematics using game-based instruction improved more than those who received traditional instruction on achievement exams. The study involved Iranian students in the 7th and 8th grades. Chang, Korosh, and Zahra (2016) conducted a study in which the impacts of game-based learning vs conventional instruction for mathematics in Taiwanese fifth-grade classrooms were compared. The study's findings showed that pupils who learned mathematics through game-based learning outperformed those who received traditional training.

In order to compare the effects of game-based and conventional mathematics instruction on students' academic achievement, Theresa (2014) conducted a study. The findings demonstrated that, in comparison to traditional instruction, game-based instruction had a beneficial impact on students' math achievement and attitudes. Furthermore, it was unaffected by gender, age, or previous math knowledge. In a study comparing game-based instruction to traditional instruction in terms of student motivation, performance, and learner satisfaction, Gunning (2014) conducted the research. The findings demonstrated that as compared to traditional training, game-based instruction was related to higher motivation, performance, and learning satisfaction.

A study by Abawi and Biehler (2014) evaluated the impact of a scaffolded math game-based learning environment on a traditional learning environment on students' academic achievement. The outcomes demonstrated that, in comparison to the traditional learning environment, the game-based learning environment had an overall favorable impact on academic performance. The findings of the aforementioned studies suggest that in terms of motivation, performance, and learning satisfaction, game-based mathematics learning is superior to conventional teaching techniques. Additionally, encouraging academic accomplishment through game-based learning is more successful, especially with kids who have no prior arithmetic background.

3.0 Methodology

The research design.

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The mixed methods explanatory research design was explored in investigating senior high school mathematics teachers' perception and use of problem-solving as a pedagogical tool. The design was employed to collect both quantitative and qualitative data from a cross-section of senior high school mathematics teachers (Creswell, 2014). This helped the researcher to address the research problem in chapter one. Literature suggests that pragmatist philosophies basically drive mixed methods designs. Pragmatism research philosophy accepts concepts to be relevant only if they support action. Pragmatics recognise that there are many different ways of interpreting the world and undertaking research, that no single point of view can ever give the entire picture, and that there may be multiple realities. According to pragmatism research philosophy, the research question is the most important determinant of the research philosophy. Pragmatics can combine both, positivist and interpretivism positions within the scope of a single research according to the nature of the research question

The pragmatic paradigm was deemed appropriate for this study because the research problem and questions informed the methodology for this research study (Davis, 2010). Following the pragmatist philosophies were the sequential explanatory mixed methods processes (Subedi, 2016). The researcher also presented the research population and sample size, sampling procedures, study area, and participants, instruments of data collection procedures, validity and reliability of instruments, and instruments of data analysis. The mixed methods research design employed the pragmatist philosophies to explain inferences, interpretations, research questions, hypotheses, and experiments. These were followed by qualitative transcripts and experiences of the models (Naidu,2013; Subedi, 2016).

In addition, the pragmatist philosophies of mixed methods research design systematically, scientifically, and logically helped to carry out the hypotheses, research questions, data collection, data analysis, deductions, and inferences (Creswell, 2012). The first process collected baseline data through questionnaires and interviews. This baseline data established the research problem and justified the kind of methodology to use. The second process explored senior high school mathematics teachers' perception and use of problem-solving as a pedagogical tool in the mathematics classroom. The third process integrated the results of the interactions and interview transcripts. This helped to corroborate, explain, and confirm the interactions. In this way, the techniques and procedures used for mixing the data provided a better understanding of the merging, integrating, and interaction processes than one. This equipped the researcher to follow up, combine, and integrate the results of the baseline survey with the main study (Harwell, 2011).

Though the literature is unclear whether both qualitative and quantitative data together constitute mixed methods or the concept should stand alone, the research employed the stand-alone mixed methods research design (Naidu, 2013). This is because the pragmatist philosophies allow for flexible approaches to solving practical problems regardless of their objective truths or subjective perceptions (Harwell, 2011). It is the best way of exploring data whose respondents are novices in the area of concern and lack the requisite knowledge and skills to provide complete and comprehensive data (Subedi, 2016).

3.2 Sampling Methods

A sample, as defined by Polit, Beck, and Hungler (2011), is a fraction of the population that is chosen for a study. It stands for a selected subset of a reachable population when essential data is needed. According to Ary et al. (2012), sampling is the process of choosing units or groups from an interested population so that results from studying the sample can be adequately generalized to the full population. The researcher's methodology or plan for selecting samples is referred to as the sampling procedure. Forty (40) students enrolled in Junior High School (JHS) 1 at Akantome made up the sample for this study. The participants ranged in age from twelve (12) to sixteen (16) years old. Twenty-five (25) boys and fifteen (15) girls made up the sample. The census approach was used, which meant that all of the pupils in the class were included as participants because the researcher intended to include the entire class in the study.

3.3 Data Collection

In order to examine the effect of game-based learning on pupil attitude and achievement, data were collected from interviews, video recordings, field notes, surveys, and pre-test, mid-test, and post-test assessments.

Game-Based Mathematics Learning Intervention

The game-based mathematics learning intervention involved the use of appropriate math games, puzzles, and interactive digital resources. The intervention was designed to align with the mathematics curriculum and cover key concepts and skills. The duration and frequency of the intervention sessions were determined based on the research timeline and logistical considerations.

Measures of Pupil's Attitude

Data on pupil attitude toward mathematics was collected through daily surveys, pupil interviews, still photographs, and researcher field notes.

Pupils' Daily Attitude Survey

The researcher designed a daily Attitude Survey to assess students' sentiments about their daily math lessons and mathematics overall. The survey included three Likert-scale questions ranging from 1 to 6, representing various emotional states. This initial survey aimed to measure individual students' attitudes toward math and provided a basis for tracking changes over time. Students completed the survey after each day of the action research instruction, allowing for regular assessment (See Appendix I).

Pupil Interviews

The researcher conducted individual interviews with 10 students to explore their attitudes toward game-based learning and its impact on their mathematics perception. The interviews were semi-structured, audio-recorded, and transcribed. Content analysis techniques were employed to identify major themes and provide valuable insights into students' attitudes toward game-based learning and its impact on their perception of mathematics.

Still Photographs and Researcher Field Notes

The researcher captured daily photographs of students engaged in activities, analyzing them to understand their attitudes toward the lesson and mathematics. The study aimed to identify specific details and patterns, such as facial expressions, body language, and number of students actively participating. This analysis provided valuable insights into students' engagement levels, emotional responses, and receptiveness to the lesson and subject matter.

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Measures of Pupils' Performance (Pretest, Mid-Test & Post-Test)
Data on students' mathematics performance in ordered pairs was collected using assessments, artifacts, interviews, and field notes for a comprehensive understanding.

Pupil Assessment
The study involved conducting a series of tests for student assessment, including a pretest, mid-test, and post-test. The pretest assessed students' understanding of the unit's content, with ten questions and a time limit of ten minutes. The mid-test involved a cross-curricular game-based activity, with 40 students participating. A class average was calculated to assess overall performance. The post-test, administered after the unit, mirrored the pretest format and content, allowing for a comparison of scores from the pretest and mid-test. This analysis provided valuable insights into students' development and achievement throughout the unit.

Pupil Artifacts
The researcher collected students' daily work and analyzed it to identify patterns and trends in their performance. This included common errors, task completion percentage, attention to detail, and overall grade. The goal was to gain insights into students' strengths, weaknesses, and overall academic progress.

3.4 Data Collection Procedure

The study used a variety of techniques to collect data, including field notes, surveys, pretest, midtest, and post-test evaluations as well as interviews. Pre- and post-assessments as well as attitude questionnaires were done on the first and last days of the five-day course. The three days in the middle were spent in class, with lessons including elements of game-based learning. The activities were planned and organized in accordance with the teaching and learning requirements of the Ghana Education Service (GES).

3.5 Tools for Data Analysis

The study used descriptive statistics, frequency, and percentage scores, and scoring in accordance with objectives to examine quantitative data. The mean difference in students' math proficiency and interest between the two teaching strategies was calculated using an ANOVA analysis. Scores from the pre- and post-tests were compared, and ANOVA and regression analysis were used to determine the impact of the game-based mathematics learning intervention. The Statistical Package for Social Sciences (SPSS) version 25.0 was used to analyze this data.

4.0 Results and Discussion

4.1 Bio-Data of the Pupils

The bio-data of the pupils include sex and age.

Table 1: Bio-Data of the Pupils

Variable	Response	Frequency	Percentage
Sex	Male	25	62.5
	Female	15	37.5
	Total	**40**	**100.0**
Age	12-14 yrs	29	72.5
	≥ 15 yrs	11	27.5
	Total	**40**	**100.0**

(Field Data, 2023)

Table 1 shows that the study had a higher percentage of male participants (62.5%) than females, with the majority aged 12-14. This gender disparity could impact the generalizability and applicability of the results. Differences in learning styles, preferences, and attitudes towards mathematics can impact how pupils engage with game-based mathematics learning and affect their academic performance (Eccles & Jacobs, 1986; Hyde & Linn, 2006). It is crucial to consider potential gender-related factors that might influence the study's outcomes, such as whether the interventions primarily targeted male students or if the study showed positive effects on academic performance.

The research highlights the importance of considering the age range of 12-14 years old for most pupils (72.5%). Adolescence is characterized by cognitive, emotional, and social changes, which can impact learning experiences (Steinberg, 2005). Understanding the specific needs and characteristics of this age group is crucial for designing effective game-based learning approaches. This allows researchers to explore the potential differential effects of game-based mathematics learning on academic performance based on age-related factors.

4.2 Effective Specific GBL Strategies for Improving Pupils' Mathematics Performance

The first objective of the study sought to identify the specific game-based mathematics learning strategies that are most effective in improving pupils' academic performance in Walebelle Junior High School.

Table 2: Specific GBL Strategies that are Most Effective in Improving Pupils' Mathematics Performance

Game	Effective Teaching and Learning Strategies
Problem-solving games	
Number Munchers Game	1. Problem-solving exercises and challenges
	2. Conceptual understanding through gameplay
	3. Practice with basic arithmetic operations
Fraction Action Game	1. Visual representations of fractions
	2. Interactive fraction manipulation
	3. Comparing and ordering fractions
Math Blaster Game	1. Gamified math drills and exercises
	2. Speed and accuracy-focused challenges
	3. Problem-solving under time constraints
Simulation games	
The Great Math Escape Game	1. Cooperative problem-solving tasks
	2. Critical thinking and logical

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	reasoning
	3. Application of math concepts in a story
The Island of Math: Game	1. Exploration and discovery of math concepts
	2. Real-life problem-solving scenarios
	3. Interactive math puzzles and challenges
Numberlympics Game	1. Competitive math challenges
	2. Timed problem-solving activities
	3. Reinforcement of arithmetic skills
Gamified learning activities	
Mathletics Game	1. Adaptive learning and personalized feedback
	2. Interactive math exercises and quizzes
	3. Tracking progress and achievements
Math Playground Game	1. Engaging in math mini-games and activities
	2. Reinforcement of various math concepts
	3. Independent exploration and practice

(Source: Author's Construct, 2023)

Table 1 displays the most effective game-based mathematics learning strategies for improving pupils' academic performance. The study identified various games, such as Number Munchers, Fraction Action, Math Blaster, The Great Math Escape, The Island of Math, Number Lympics, Mathletics, and Math Playgrounds, as effective strategies. This aligns with previous research highlighting the efficacy of game-based learning in enhancing student achievement. Clark et al. (2014) found that the Mathletics game significantly improved students' mathematics performance compared to traditional instruction. This supports the notion that specific game-based learning strategies, like Mathletics, can positively influence students' academic performance in mathematics. Similarly, Liu et al. (2017) found that game-based learning strategies, such as Math Blaster and Math Playground, improved students' mathematics performance. Participants achieved higher scores in assessments compared to traditional instruction, indicating the potential for game-based learning to improve academic performance in mathematics.

The research findings on specific mathematics games for teaching and learning show their effectiveness in improving pupils' performance in mathematics. These games, such as number munchers, fraction action, and the great math escape, can enhance academic achievement in mathematics. However, it is crucial to consider limitations and context, such as sample size, game mechanics, and intervention duration, to fully understand the effectiveness of these strategies. Previous studies by Clark et al. (2014) and Liu et al. (2017) have also highlighted the positive impact of game-based learning on students' mathematics achievement.

4.3 Influence of Game-Based Mathematics Learning on Pupils' Attitudes Towards Mathematics

The study aimed to investigate the influence of game-based mathematics learning on Walembelle Junior High School students' attitudes toward mathematics. Data were analyzed using descriptive and inferential statistics, and changes in attitudes were assessed from pre-intervention to post-intervention. Common trends were examined through open, axial, and selective coding methods. The baseline and post-intervention surveys were coded separately, and average percentages were calculated from 40 daily survey participants.

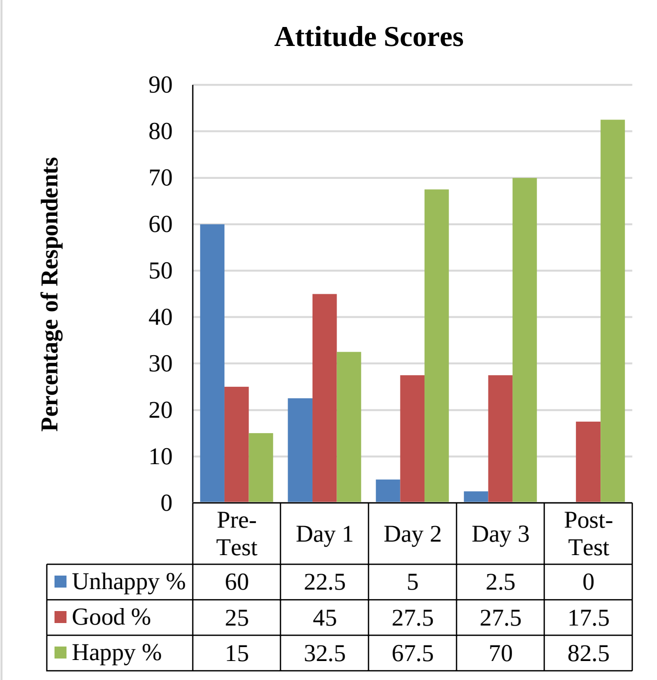

Figure 1: Measures of Attitude: Daily Attitude Surveys
(Source: Field data, 2023)

The study shows that game-based mathematics learning positively influences students' attitudes toward the subject. Initially, 60% of students disliked math, while 15% enjoyed it. However, after the intervention, 82.5% of students enjoyed mathematics. By the end of instruction, 100% of students expressed positive feelings towards math, indicating a positive impact on their attitudes. Game-based learning as noted by Rieber (1996) enhances motivation and engagement, which are crucial factors in shaping students' attitudes towards a subject. By integrating educational content into a game-like environment, students experience enjoyment, challenge, and intrinsic motivation, leading to more positive attitudes toward learning.

Huang's (2016) study found that game-based learning significantly improved primary school students' attitudes towards mathematics, leading to increased enjoyment and interest. The study supports the notion that game-based learning can positively influence pupils' attitudes towards the subject. The 100% positive response by the

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end of instruction demonstrates the transformative power of game-based mathematics learning in shaping students' attitudes. However, factors like intervention duration, approach, and sample size must be considered to fully understand the impact of game-based learning on attitudes toward mathematics.

In summary, the findings showed that game-based learning significantly improves pupils' attitudes towards mathematics, aligning with previous literature. Studies by Rieber (1996) and Huang (2016) highlight its positive influence on motivation and enjoyment, leading to more positive attitudes towards the subject.

Table 3: Relationship between GBL and Students' Attitudes Toward Mathematics

Students' Attitude towards Mathematics	Unstandardized Coefficients		Standardized Coefficients	t	Sig. (prob)
	B	SE	Beta		
(Constant)	0.878	.365		2.409	.017
Attitude after Intervention	1.012	.144	.480	7.014	.000
Attitude before Intervention	-0.336	.131	-.176	-2.570	.011
Model Summary & ANOVA					
R	0.447[a]				
R^2	0.200				
Adjusted R^2	0.192				
SEE	1.275				
F-ratio	24.597				
Sig.	0.000[b]				

a. Dependent Variable: Game-Based Mathematics Learning
b. Predictors: General attitude, Today's attitude (Source: Field data, 2023)

Table 3 shows a significant association ($p < 0.05$) between game-based learning and students' attitudes toward mathematics. The research found that traditional methods had an inverse effect (B = -0.336) on students' attitudes, while game-based teaching and learning positively impacted them (B = 1.012). Studies, such as Durmuş and Karakuş's (2018), support the idea that game-based learning can positively influence students' attitudes toward mathematics. In primary school settings, pupils who engaged in game-based learning demonstrated more positive attitudes than those who received traditional instruction. Overall, game-based learning has a positive impact on pupils' attitudes toward mathematics. Similarly, A meta-analysis by Hwang et al. (2019) found that digital game-based learning significantly positively impacts pupils' attitudes towards mathematics, promoting improved motivation and motivation. The study suggests that game-based learning can reverse the negative impact of traditional teaching methods and foster positive attitudes toward mathematics.

In summary, the research findings showed a significant association between game-based learning and pupils' attitudes towards mathematics. Studies by Durmuş and Karakuş (2018) and Hwang et al. (2019) highlight the positive impact of game-based learning on pupils' attitudes, highlighting its potential as an effective approach to fostering positive attitudes.

Pupil Interviews

In the pupil interviews, all ten students expressed their enjoyment of math when it was taught in the form of a game. Three major trends emerged from the interviews: increased growth mindset, improved problem-solving skills, and higher student engagement. Regarding the growth mindset, students demonstrated a positive shift in their views about math. They acknowledged their progress with comments like, "I am getting so much better at math now," and "I understand so much more now." This indicates that they started seeing math as a skill that can be developed through effort and dedication. Even those who believed they were bad at math initially now felt that they could succeed with more fun and engaged practice. The interviews also highlighted the enhancement of problem-solving skills through partner interaction. pupils enjoyed working with partners because it allowed them to consider different perspectives. They appreciated being able to talk out loud while thinking through problems, and helping their partners understand their mistakes. This collaborative approach fostered better problem-solving abilities.

Lastly, pupils reported increased engagement in math lessons when game-based, as it provided a fun and interactive approach. This style relieved the pressure and made math enjoyable, encouraging pupils to try new subjects. The game-based learning style also reduced initial aversion to math, resembling Hunt's findings (1985) and reducing math anxiety and negative attitudes. Leroy and Bressoux (2016) confirmed low math self-esteem is linked to poor achievement in math class.

Still Photographs and Researcher Field Notes

The researcher utilized two methods to observe and record pupils' attitudes during instruction: researcher field notes and still photographs. The field notes provided some valuable information about individual pupil attitudes on a daily basis. However, they had limited data on whole-class student attitudes. In contrast, the daily still photographs captured by the researcher on a digital camera offered detailed insights into daily student attitudes. Out of the forty photographs taken during the unit, five wide shots of the entire class were particularly revealing. In these photos, every visible student was fully engaged and on task, indicating high levels of student engagement and achievement during the lessons. These photographs provided a comprehensive view of the overall class attitude, complementing the individual insights from the field notes.

4.4 Effectiveness of Game-Based Mathematics Learning on the Academic Performance of Pupils as Compared to the Traditional Learning Method

The study aimed to compare game-based mathematics learning at Walembelle Junior High School to traditional methods. Data was

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collected through pretest, midtest, and posttest assessments, analyzing pupils' computational performance before, during, and post-intervention. The mean scores are presented graphically.

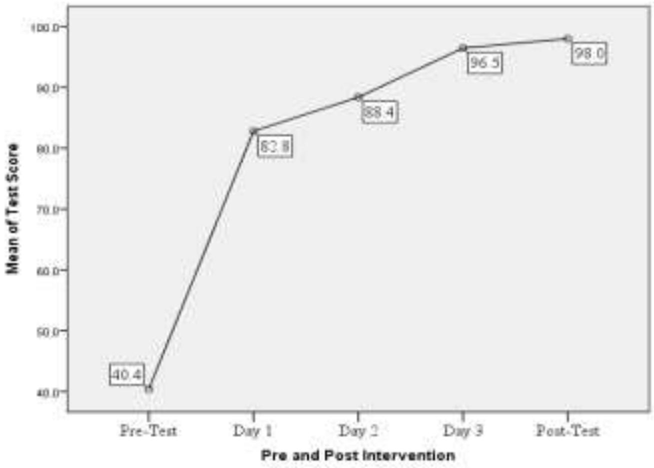

Figure 2: Computation of Pupils Performance
(Source: Field data, 2023)

Figure 2 illustrates the mean scores of the pupils for pre-, mid-, and post-intervention. The research shows a significant improvement in pupils' mathematics assessments after a game-based learning intervention, with an average score of 40.4% on pre-test and 98.0% on post-intervention. This indicates that game-based learning is more effective than traditional methods in improving academic performance. Previous studies, such as Smetana and Bell's (2012), found that pupils who participated in a game-based learning environment achieved higher scores compared to those who received traditional instruction. This supports the notion that game-based learning can be more effective than traditional methods in improving academic performance in mathematics. Similarly, a meta-analysis by Wouters et al. (2013) found that digital game-based learning significantly improves mathematics achievement in K-12 education, highlighting its effectiveness as an instructional approach for academic improvement.

The study shows a significant increase in pupil scores from pre-intervention to post-intervention, indicating the efficacy of game-based mathematics learning compared to traditional methods. However, the research lacks specific information on sample size, study design, and factors like duration, pupil engagement, and long-term sustainability of the observed improvements. The research showed a significant increase in pupil scores in mathematics assessments after game-based learning intervention. Studies by Smetana and Bell (2012) and Wouters et al. (2013) emphasize the positive impact of game-based learning on mathematics achievement, indicating its potential as a promising approach to improve academic performance.

Artifacts

The researcher collected artifacts from pupils' written work, assessing their effort and accuracy. On the first day, pupils participated in Coordinate Battleship, achieving an 84 percent class average. On the final day, they engaged in five stations with activities and games related to the coordinate plane, demonstrating proficient knowledge of ordered pairs. The artifacts showed a 96% class average for the day, indicating strong performance and understanding of the subject matter.

Table 4: One-Way ANOVA Analysis of Difference in Pupils' Performance between Pre and Post-Intervention

Pre and post-intervention	N	Mean	Std. Deviation	Std. Error	F	Sig.
Pre-Intervention	40	40.400	13.1847	2.0847		
Day 1	40	82.800	19.2822	3.0488		
Day 2	40	88.375	14.2625	2.2551	129.6	0.000
Day 3	40	96.450	9.6475	1.5254		
Post- Intervention	40	98.000	4.4491	.7035		
Total	**200**	**81.205**	**24.8568**	**1.7576**		

(Source: Field data, 2023)

Table 4 illustrates the significance of the mean difference in pupils' mathematics performance for pre-and post-intervention. The study found a statistically significant difference in students' mathematics performance before and after game-based learning, indicating that it is highly unlikely to have occurred by chance alone. Game-based learning, an innovative approach to education, integrates educational content into game-like environments to enhance pupil engagement and learning outcomes. This finding aligns with previous research demonstrating the positive impact of game-based learning on various academic domains, including mathematics. One study by Ke, Kwak, and Kim (2014) found that students who engaged in game-based learning demonstrated significantly higher mathematics achievement compared to those in traditional instruction groups, supporting the notion that game-based learning can lead to improved performance in mathematics.

Similarly, Clark et al. (2016) found that game-based learning in high school mathematics classrooms led to greater gains in performance compared to traditional instruction. Boyle et al.'s (2016) meta-analysis also found a significant positive effect of game-based learning on academic achievement across various subjects, supporting the notion that game-based learning is an effective instructional approach for improving mathematics performance. In summary, the research shows a significant difference in pupils' mathematics performance before and after game-based learning, consistent with previous studies. This highlights the positive impact of game-based learning on mathematics achievement, highlighting its potential as a valuable educational tool.

5.1 Summary of Key Findings

Based on the research findings and discussion, the key findings of the study are summarised below:

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1. The study found that games like **number munchers, fraction action games, and** emojilicious coordinates story games are effective in improving students' mathematics achievement.
2. The research findings revealed a direct positive influence of game-based learning on pupils' attitudes toward mathematics which supports existing literature on the positive influence of game-based mathematics learning.
3. The study found a significant increase in student scores on mathematics assessments after the introduction of a game-based learning intervention, which supports existing literature on the effectiveness of game-based mathematics learning.

5.2 Conclusion

The study suggests a strong connection between game-based learning (GBL) and improved pupil attitudes and achievements in mathematics. However, the study has limitations in terms of sample size, duration, and content focus. To gain more insightful results and control for other factors, further research is needed. Despite the limitations, the study's results have significant implications for teachers and students. Participants showed notable improvements in math attitudes and ordered pairs achievement, supporting existing literature on serious games' positive impact. These findings encourage continued research and adoption of GBL in instruction, as the teacher-researcher plans to do.

5.3 Recommendations

Based on the findings of the study, the following recommendations were suggested:

1. Teachers should implement Game-Based Learning (GBL) in Mathematics Instruction. Based on the study's findings, educators should consider incorporating game-based learning activities into their mathematics classrooms. GBL can help improve student attitudes and achievements in math, making the subject more enjoyable and engaging for pupils.
2. The Ghana Education Service should provide professional development for teachers. Authorities in education should provide professional development opportunities for teachers to learn about the effective use of game-based learning in the mathematics curriculum. Training sessions can equip teachers with the necessary skills and strategies to integrate GBL effectively into their lessons.
3. Future researchers should conduct larger-scale studies. To overcome the limitations of the current study, educational authorities and research institutions should fund larger-scale studies. Increasing the sample size and extending the duration of the research would provide more reliable and generalizable results on the impact of GBL on pupil outcomes.
4. Future researchers should conduct Control group studies: Researchers should conduct controlled experiments with a control group to compare the effects of game-based learning against traditional instructional methods. This would allow for a more rigorous evaluation of the effectiveness of GBL in comparison to other approaches.

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