

Effect of Game-Based Instructional Method on Preschoolers' Arithmetic Achievement in Lagos State

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Abstract

This study evaluated how game-based learning affected preschoolers' arithmetic achievement. Quasi-experimental research design was adopted and the study population include public nursery school pupils in Lagos Mainland L.G.A. of Lagos State, and the sample size was 34 pupils in two randomly selected Nursery Two classes from two public nursery schools. A class of 18 was the treatment group and a class of 16 was the control group. This study used a 13-item Preschoolers' Arithmetic Achievement Test (PAAT) validated by early childhood education and test and measurement experts at the University of Lagos, Akoka, with a Cronbach Alpha reliability value of 0.87 to assess the group's arithmetic achievement. Frequency counts and independent-samples t-tests were used in SPSS 21.0 to analyse the data at 0.05 significant levels. The P-value of 0.412 was found greater than the level of significance (0.05); $p > 0.05$. The results demonstrated that game-based instructions improved preschoolers' arithmetic achievement in Lagos Mainland and that gender did not affect performance. Based on the findings, this study recommends integrating game-based instructional methods into preschoolers' teaching-learning process and encourages curriculum workers and examination bodies to popularise its efficient utilisation.

Keywords: Game-based instructions, Arithmetic Achievement, Preschoolers, Teaching-Learning Process

Arithmetic holds significant importance in all areas of human activity and study (Maduabum & Odili, 2016). It has consistently played a crucial part in the advancement of both persons and nations. Arithmetic is an

indispensable tool required for efficient functioning in the current technology era (Aremu, 2018). Even the average individual will acknowledge the fact that knowledge of numbers is crucial for the existence of humanity. Abakpa and Iji (2021) state that arithmetic is a cognitively stimulating discipline that has an impact on several aspects of human activities, including economics, politics, science, and technology.

The importance of early childhood education (ECE) on cognitive development, especially in arithmetic, is widely acknowledged. Proficiency in arithmetic from early childhood is not only critical for achieving scholastic attainment in mathematics, but also plays a central role in the advancement of critical reasoning and problem-solving abilities, which are vital for everyday life. Although crucial, conventional teaching techniques used in preschool environments frequently depend extensively on memorisation through repetition and monotonous exercises. Although these strategies have shown some effectiveness, they have been criticised for being unable to actively engage young learners and promote an extensive understanding of mathematical topics (Clements & Sarama, 2021).

Due to the constraints of conventional teaching approaches, there has been an increasing curiosity with game-based instructional methods, especially in the field of early childhood education. Game-based learning incorporates the use of play in the classroom, using children's inherent desire to play as a method to facilitate learning. The foundation of this technique is based on Jean Piaget's (1963) Constructivist Theory which posits that children actively construct their own knowledge and understanding through hands-on experiences and social interactions. Games, with their inherent components of difficulty, rivalry, and gratification, offer an optimal platform for such educational encounters. Studies have demonstrated that game-based learning not only increases involvement but also promotes the ability to remember and apply knowledge. This is because it corresponds with children's natural inclination to explore and learn via play (Plass, Homer, & Kinzer, 2015).

The present study focusses on Lagos Mainland L.G.A., Lagos State, where the potential of game-based instructional methods in teaching mathematics to young children has not been thoroughly investigated. Prior

studies conducted in different settings have shown that game-based learning has the capacity to greatly enhance arithmetic abilities in young children. For example, a study conducted by Ramani and Siegler in 2018 discovered that engaging in numerical board games or puzzles resulted in significant improvements in number sense among low-income children in the United States. In a similar vein, Laski and Siegler (2024) found that children who participated in numerical games or puzzles had enhanced counting abilities and a more profound comprehension of numerical magnitudes. Nevertheless, these studies were predominantly carried out in Western environments which prompt enquiries over the applicability of their results to diverse cultural and educational settings, such as Nigeria.

There is an urgent requirement in Nigeria, namely in Lagos Mainland, to investigate inventive teaching methods that can improve the standard of early childhood education. Implementing game-based educational strategies shows potential for enhancing math performance in preschool children. However, there is a scarcity of empirical information regarding its efficiency in the Nigerian setting. The dearth of research in this area highlights the significance of doing research that is tailored to the specific setting in order to assess the effects of these instructional strategies on the arithmetic performance of preschool children.

Arithmetic plays a crucial role in education, especially in preschool settings, as it establishes the basis for future mathematical proficiency. Preschool arithmetic generally covers fundamental numerical concepts, including counting, number recognition, comprehension of quantity, and basic addition and subtraction. These notions have a crucial role in the cognitive development of children, as they improve their problem-solving skills and logical reasoning.

Studies indicate that proficiency in basic mathematical operations during early education is a reliable indicator of future academic success, not only in mathematics but also in other academic disciplines (Duncan *et. al.*, 2017). Arithmetic is commonly taught in preschool settings through interactive and enjoyable activities that are tailored to the developmental stage of young learners. This method not only enhances the enjoyment of learning but also facilitates the internalisation of mathematical concepts in

children through the use of repetition and hands-on experiences (Clements & Sarama, 2021).

Additionally, there is a strong emphasis on utilising tangible objects and visual aids to assist preschoolers in comprehending complex mathematical ideas. For example, employing blocks as a means to illustrate addition and subtraction enables children to visually understand the procedure, thus promoting better understanding (Ginsburg, Lee, & Boyd, 2018). Integrating mathematics into preschool curriculum is vital since it establishes the foundation for more advanced mathematical learning in subsequent years, rendering it a fundamental component of ECE.

Young children learn science and mathematics most effectively through active engagement in hands-on activities, as shown by research conducted by Salami (2014), Moravick, Nolte, and Feneey (2013), and Ogunsanwo (2003). A game-based technique can be defined as an educational approach that promotes learning by actively immersing and engaging children in various age-appropriate, developmentally suitable, and culturally appropriate games to teach or explain concepts. According to Trybus (2015), game-based strategy involves taking specific ideas from games and using them in real-life situations to actively involve consumers. O'Connor *et. al.*, (2021) posited that game-based approach is the use of games in classrooms to achieve educational goals. These games can encompass both enjoyable and informative elements.

Game-based instruction is an educational tool that incorporates audio-visual elements, animations, films, and games to facilitate student interaction (Chen, *et. al.*, 2019). Instructional games encompass a wide range of games that can be utilised to enhance the process of learning. These include board games, computer games, games created locally or commercially, tangible games, puzzle-based games, internet games, card games, and more. Instructional games can serve as a supplementary tool to enhance the learning process for pupils, in addition to teaching those valuable skills such as rule-following, adaptability, problem-solving, communication, creativity, critical thinking, teamwork, and good sportsmanship (Zirawaga, *et. al.*, 2017).

Research conducted by Spires, Rowe, Mott, and Lester (2021) has demonstrated that educational games effectively bridge the gap between scientific knowledge and real-life situations. According to Schaaf (2022), game-based learning is most efficient when it corresponds with the requirements of students and the substance of the curriculum. In their study, Liu and Chen (2023) found that primary school students acquire science-related concepts through active engagement in educational card games. Educational academics have shown interest in incorporating puzzle games into science classes, as evidenced by studies conducted by Scott (2016) and Bowers (2016).

According to Letuna (2021), teachers often employ game-based learning once or twice a month to inspire students and enhance their skills. This approach is based on the recognition of the important role that games play in teaching. The infrequent usage of game-based learning motivated its adoption in the study.

This study employs the Jean Piaget's (1963) Constructivist Theory which asserts that children actively construct their own knowledge and understanding through hands-on experiences and social interactions. According to Piaget, children progress through four stages of cognitive development: sensorimotor, preoperational, concrete operational, and formal operational. In the context of arithmetic learning, Piaget's theory suggests that preschoolers in the preoperational stage (2-7 years) learn best through concrete, manipulative experiences that allow them to explore and understand mathematical concepts. Game-based instructional methods align with Piaget's theory by providing interactive, engaging, and concrete experiences that enable preschoolers to construct their understanding of arithmetic concepts, such as numbers, shapes, and patterns.

Piaget's theory also emphasizes the importance of accommodation and assimilation in the learning process. Accommodation refers to the process of adjusting existing mental frameworks to incorporate new information, while assimilation involves integrating new information into existing knowledge structures (Flavell, 2020). Game-based instructional methods facilitate both processes by presenting arithmetic concepts in a playful,

interactive manner that challenges preschoolers to adapt and refine their understanding. For instance, a math game that involves counting blocks or shapes helps preschoolers accommodate new information about numbers and quantities, while assimilating this knowledge into their existing understanding of arithmetic concepts. By aligning with Piaget's Constructivist Theory, game-based instructional methods can enhance preschoolers' arithmetic achievement by providing a learner-centered, interactive, and engaging environment that fosters active construction of knowledge.

Mathematics education researchers have documented several factors contributing to the underachievement in mathematics among secondary school students. For example, according to Unodiaku (2010) and Ogbuanya (2019), the reason for students' low achievement in mathematics is the insufficient preparedness of primary school pupils to continue learning mathematics at the secondary school level. Similarly, Unodiaku (2021) stated that the want to learn mathematics is a contributing factor to success in mathematics education.

Ogbuanya (2019) states that a lack of sufficient or solid foundation in earlier grades is a major factor that diminishes children's enthusiasm for mathematics. Additionally, many teachers employ unsuitable approaches when teaching mathematics and interacting with students. Usman and Nwoye (2010) found that incorporating games into mathematics instruction can stimulate students' interest in the subject and lead to improved performance. The study suggested that an effective approach to fostering enduring student interest in arithmetic is through the use of diverse methodologies, educational resources, and procedures, particularly through the incorporation of games. In addition to enhancing the attraction of mathematics education, it will also enhance students' performance in mathematics.

Kebritchi, *et. al.*, (2018) found that there has been a rise in the use of games by kindergarten teachers for improving learning. Games are efficient tools for training complex ideas because they rely on practice rather than explanation, provide individual fulfilment and motivation, present different learning abilities and styles, enhance proficiency, and offer engaging texts that allow users to make their own decisions (Holland,

Jenkins & Squire, 2002; Charles & McAlister, 2004). Pernsky (2001, cited in Kebritchi *et. al.*, 2018) suggests that computer games have the potential to establish a novel learning culture that aligns with the behaviours of both children and adults.

The gender of learners is a variable that is believed to have an impact on the acquisition of scientific knowledge in pre-primary schools. Contemporary psychological research has demonstrated that gender, when considered as a variable, is associated with performance (Ezeugo & Agwagah, 2020). According to Adeleke (2018, as cited in Majebi & Akin 2023), the majority of researchers have seen that boys tend to outperform girls, particularly in higher order knowledge. However, a minority of researchers have discovered that girls perform better than boys, while some others have shown no significant difference, especially in early education.

Wei, Sopory and Hendrex (2019) assessed the impact of competitive and noncompetitive instructional mathematics games on the ability of boys and girls aged four to seven to remember their gaming experience. The findings indicated that the learning outcomes of both boys and girls were enhanced following both competitive and non-competitive activities.

Research conducted by Bilesanmi-Awoderu, (2016); David, Kumar, Stanley, and Helgeson, (2020); Freedman, (2022), has found that there are no longer significant disparities in the affective, cognitive, and psychomotor skill achievements of students based on gender. In their study, Oludipe and Oludipe (2018) found that students' academic performance in sciences was not influenced by gender. Although there was a small disparity in the average scores of female (24.89) and male (23.66) pupils on the post-test, this difference was not statistically significant.

This study seeks to examine the impact of game-based instructional approaches on the arithmetic performance of preschoolers in Lagos Mainland L.G.A., Lagos State. The study aims to add to the wider discussion on successful teaching methods in early childhood education and offer insights that can influence educational policies and practices in Nigeria. This research is anticipated to provide evidence-based

suggestions that could assist educators and policymakers in improving the quality of mathematics education in Nigerian preschools.

Objectives of the study

The objectives of the study are to:

- I. Investigate the effect of game-based instructions on preschoolers' arithmetic achievement in Lagos Mainland.
- ii. Examine the influence of gender on preschoolers' arithmetic achievement in Lagos Mainland using game-based instructions.

Research Questions

- i. Does game-based instruction have a significant effect on preschoolers' arithmetic achievement in Lagos Mainland?
- ii. Is there a significant difference in the arithmetic achievement of male and female preschoolers in Lagos Mainland using game-based instructions?

Research Hypotheses

The following hypotheses were tested at 0.05 level of significant in this study:

- H₀1:** There is no significant effect of game-based instructions on preschoolers' arithmetic achievement in Lagos Mainland
- H₀2:** There is no significant effect of gender on preschoolers' arithmetic achievement in Lagos Mainland using the game-based instructions

Methodology

The study adopted quasi-experimental research design. The study used one treatment and one control group of intact classes. The treatment group received game-based instruction while the control group received traditional instruction. The study population included public nursery school pupils in Lagos Mainland L.G.A. of Lagos State, and the sample size was 34 pupils in two randomly selected Nursery Two classes from two public nursery schools. The treatment group was 18 pupils and the control

group was 16 pupils. In this study, Nursery two pupils learn basic addition utilising a numerical board game for the treatment group and the traditional technique for the control group.

The control group learnt basic addition using chalk-and-talk. The researcher wrote numbers on the board and showed how to add single-digit numbers with counters, fingers, and pictures. Student participation involved solving simple addition problems on the board and in their notebooks. The goal was repetitious practice, with worksheets offering simple addition problems ($2 + 3 = 5$) to be solved independently.

The treatment group learnt basic addition with a numerical board game that was made just for them. The game board had spots with numbers from 1 to 20 on them. Pupils were told to roll a die and move their game pieces based on the number that came up. At each stop, they had to pick up a card and solve an addition problem. The child has to solve the addition puzzle on the card once they land on a certain spot after tossing the dice. Take the example of a pupil who rolls a 4 and moves their piece four spaces forward. They might end up on a spot that matches a card that says " $3 + 2$." The pupil then has to correctly solve " $3 + 2 = 5$ " in order to keep playing.

Both groups were given an equal amount of instruction for duration of two weeks. Their proficiency in basic addition was evaluated by pre- and post-tests to determine the efficacy of each teaching approach. This study utilised a 13-item Preschoolers' Arithmetic Achievement Test (PAAT) that was validated by experts in early childhood education and test and measurement at the University of Lagos, Akoka. The test demonstrated a good level of reliability, as shown by a Cronbach Alpha reliability value of 0.87. The PAAT was administered to the two groups separately before the two-week teaching took place and was readministered to them after the two-week teaching of Basic Addition. The data collected were analysed in SPSS 21.0 using frequency counts and independent-samples t-tests, with a significance threshold of 0.05.

Results

Table 1
Pupils' Demographics

Characteristics	Options	Treatment (%)	Control (%)
Gender	Male	8(44.4)	9(56.2)
	Female	10(55.6)	7(43.8)
	Total	18(100.0)	16(100.0)
Age	3-4 years	12(66.7)	11(68.8)
	5-6 years	6(33.3)	5(31.2)
	Total	18(100.0)	16(100.0)

Source: Field Survey, 2024

Table 1 above shows the demographic characteristics of the pupils. Concerning their gender, most (55.6%) of the treatment group were female and the remaining 44.4% of them were male, while the majority (56.2%) of the pupils in control group were male and the remaining 43.8% of them were female. With respect to their ages, 33.3% of the pupils in the treatment group were 5-6 years and the majority (66.7%) of them were 3-4 years. On the other hand, the majority (68.8%) of the pupils in the control group were 3-4 years and the remaining 31.2% of them were 5-6 years. These indicate that the two genders were well represented among the groups, while the pupils were also within the age range for Nursery two in Nigeria.

Test of Hypotheses

The research hypotheses were tested with the use of independent samples t-test, as shown below:

Hypothesis One: There is no significant effect of game-based instructions on preschoolers' arithmetic achievement in Lagos Mainland

Table 2
T-Test Statistics

Test	Group	N	Std.	Df	P-val.	Level	Decision
Pre-test	Treatment	18	4.22	0.37	0.412	0.05	Not Significant
	Control	16	4.63	0.35			
Post-test	Treatment	18	10.21	0.71	0.001	0.05	Significant
	Control	16	7.11	0.12			

$P\text{-value} = 0.001 < \text{level of significance}$

Table 2 shows the evaluation of the mean scores of the treatment and control groups, indicating the arithmetic achievements for both the pre-test and post-test. The pre-test, which was meant to establish whether there was any meaningful difference between the groups' achievements before the 2-week teachings indicated that the control group had a slightly higher mean score of 4.63 than the treatment group with a lower mean score of 4.22. Furthermore, a mean score of 4.63 from 16 pupils in the control group and a mean score of 4.22 from 18 pupils in the treatment group indicates that the control group was 0.41(9.7%) higher than the treatment group. More so, the P-value of 0.412 was found greater than the level of significance (0.05); $p > 0.05$. This implies that there was no significant difference between the groups' achievements before the 2-week teachings, hence, their residual knowledge on Basic Addition were not significantly different.

On the other hand, the post-test results indicate that the treatment group had a higher mean score of 10.21 than the control group with a lower mean score of 7.11. Furthermore, a mean score of 10.21 from 18 pupils in the treatment group and a mean score of 7.11 from 16 pupils in the control group indicates that the treatment group was 3.1(43.6%) higher than the control group. More so, the P-value of 0.001 was found less than the level of significance (0.05); $p < 0.05$. Thus, the null hypothesis that states “there

is no significant effect of game-based instructions on preschoolers' arithmetic achievement in Lagos Mainland” is rejected, and its alternative that states “there is a significant effect of game-based instructions on preschoolers' arithmetic achievement in Lagos Mainland” is accepted.

Hypothesis Two: There is no significant effect of gender on preschoolers' arithmetic achievement in Lagos Mainland using the game-based instructions

Table 3
T-Test Statistics

Gender	N	Std.	Df	P-val.	Level	Decision
Male	8	10.12	0.12	0.524	0.05	Not Significant
Female	10	10.30	0.14			

$P\text{-value} = 0.004 < \text{level of significance}$

Table 2 shows the evaluation of the mean scores of the male and female pupils in the treatment group, indicating their arithmetic achievements in post-test. The table showed that the male pupils had a slightly lower mean score of 10.12 than the female group with a mean score of 10.30. Furthermore, a mean score of 10.30 from 10 female pupils in the treatment group and a mean score of 10.12 from their male counterparts indicates that the female pupils was 0.18(1.8%) higher than the male pupils in the same group. More so, the P-value of 0.524 was found greater than the level of significance (0.05); $p > 0.05$. This implies that the null hypothesis that states “there is no significant effect of gender on preschoolers' arithmetic achievement in Lagos Mainland using the game-based instructions” is not rejected, indicating that pupils' arithmetic achievement was not affected by their gender provided they are under the same teaching-learning conditions.

Discussion of Findings

From the test of the first hypothesis, it was found that there is a significant effect of game-based instructions on preschoolers' arithmetic achievement in Lagos Mainland. This implies that the pupils taught with the game-

based instructional method achieved significantly higher than their counterparts taught with the conventional method. This supports Kebritchi *et. al.*, (2018)'s observation that kindergarten teachers are using games more to improve learning. Games are effective for teaching complex ideas because they focus on practice rather than explanation, motivate individuals, accommodate different learning styles, improve proficiency, and provide engaging texts that let users make their own decisions. Pernsky (2021, referenced in Kebritchi *et. al.*, 2018) indicates that games can create a new learning culture that matches children's and adults' behaviours.

From the test of the second hypothesis, it was found that pupils' arithmetic achievement was not affected by their gender provided they are under the same teaching-learning conditions. Wei, Sopory and Hendrex (2019) found that competitive and noncompetitive instructional mathematics games help four- to seven-year-old boys and girls recall their games. Both boys' and girls' learning results improved after competitive and non-competitive activities. Implying that male and female student performance is similar. Bilesanmi-Awoderu (2016); David, Kumar, Stanley, and Helgeson (2020); and Freedman (2022) discovered no longer significant gender differences in student affective, cognitive, and psychomotor skill accomplishment. Oludipe and Oludipe (2018) found no gender effect on scientific performance. On the post-test, female (24.89) and male (23.66) students scored slightly differently, but not significantly.

Conclusion

Overall, this study has shown that using game-based instruction greatly improves the arithmetic performance of preschoolers. The results suggest that children who were taught using game-based teaching methods achieved significantly higher performance compared to those who were taught using traditional instructional approaches, emphasising the efficacy of immersive and interactive learning strategies in ECE. Moreover, the study found that gender has no impact on arithmetic performance when children are subjected to similar teaching and learning circumstances. This indicates that the game-based instructional method is equally efficacious for both males and females, further emphasising its potential as

an inclusive and influential teaching strategy. These findings support the idea of include game-based learning in preschool curriculum to enhance arithmetic skills, which in turn establishes a solid basis for future academic achievement.

Recommendations

Base on the findings of the study, the researchers considered it imperative to give practicable recommendations, as follows:

1. It is important to educate teachers in primary schools on the use of an interest-oriented game-based instructional strategy for teaching arithmetic to children. Sensitisation can be achieved by conducting structured workshops, seminars, and conferences for primary school teachers. These events can be organised by government agencies like the Ministry of Education, as well as professional associations like the Mathematics Association of Nigeria (MAN) and the Science Teachers Association of Nigeria (STAN). When conferences, seminars, and workshops are organised for primary school teachers and they attend, there is a propensity for them to learn new approaches in mathematics education.
2. The curriculum designers and authors of primary school arithmetic textbooks should use a game-based instructional model as a technique of instruction.
3. Examination authorities like the Lagos State Universal Basic Education Board (LASUBEB) should incorporate questions related to mathematical games in their assessments of candidates. In addition, the Ministry of Education should incorporate arithmetic games-based questions into the assessment of preschoolers and primary school pupils

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