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## Effect of Mathematical Games on Senior Secondary School Students' Achievement in Mathematics According to Gender

Olajumoke Olayemi Salami  
*University of Johannesburg*

Erica Dorethea Spangenberg  
*University of Johannesburg*

**ABSTRACT** Playing mathematical games helps many senior secondary school students—especially girls—acquire basic mathematical skills, but it can be difficult. Thus, this study examined how gender-related mathematical gameplay affects secondary school students' performance. The design of the study was quasi-experimental. Purposively, a sample of fifty senior secondary school students from the Federal Capital Territory (FCT) of Nigeria's Abuja Council Area was chosen. The researcher randomly allocated intact classes to the experimental and control groups using a coin toss. The students' achievement level was determined by an algebraic achievement test administered before and after the treatment. T-tests, means, and standard deviation were used to analyze the data. According to the study, female students had a higher mean score than male students when playing mathematics games. The findings imply that mathematical games enhance mathematics teaching and learning and should therefore be used by teachers to introduce concepts in mathematics to students of all levels, irrespective of their gender.

**KEYWORDS** *Games, Students, Achievement, Mathematics, Gender*

### Introduction

Mathematics is an essential component of educational curricula in most countries. It provides the foundation for logical reasoning, problem solving, and technological innovation. Mathematics is important in many fields, including physics, engineering, economics, and computer science, since it enhances cognitive abilities. Also, Nigeria advocates mathematics as a subject of choice in the secondary school system to prepare students for postsecondary education and to create a workforce for job growth and national development.

However, all parties involved in education, especially mathematics teachers, parents, and the government, are currently very concerned about students' generally low academic achievement in mathematics at this level (Hursen & Bas, 2019). In Nigeria, there is a persistent reporting of students' low mathematics achievement

on internal and external examinations. For example, according to the 2019 West African Examination Council (WAEC) report, more than 66% of Nigerian students still need to pass the Senior Secondary School Certificate Examination (SSCE) in mathematics. Additionally, the percentage of SSCE passes with credit and above was 39.5%, 37.5%, 34.2%, and 37.6% in the years 2020, 2021, 2022, and 2023, respectively (WAEC Examiners' Reports, 2020-2023).

Although there are many applications of mathematical concepts in different professions and facets of life, students still perceive mathematics as a challenging subject to learn and a difficult course to pass. The fact that mathematics is usually considered difficult is one of the reasons why students are reluctant to study it in depth (Nicol, 2017). Many students find mathematics complex and scary due to its abstract nature. Students, particularly female students, are inclined to choose not

to study mathematics as soon as possible. In addition, many students have negative attitudes toward mathematics, which may significantly impact career choices and contributions to wider society (Ayebole et al., 2020). A strategy to change students' beliefs about mathematics could be mathematical games.

Ogunkola and Knight (2019) opined that mathematical games used in the classroom might positively influence students' academic achievement in science and mathematics. Thus, studies on the impact of games on students' achievement in science have drawn the attention of numerous researchers (Ayebole et al., 2020; Moon & Ke, 2020; Rigelman & Lewis, 2023).

In Nigeria, mathematics games enhance learning by creating an engaging environment and promoting active participation and problem-solving skills (Aduwa, 2021). Research shows that game-based learning positively influences mathematical achievement by providing immediate feedback, encouraging perseverance, and fostering a positive attitude toward mathematics (Akanmu & Adeniyi, 2021). Mathematical games are practical activities that bring about fun, excitement, and challenges between two or more contestants and simultaneously enhance mathematics learning (Khateeb, 2019). Games are mathematical if their strategies, rules, and results are well-defined by mathematical parameters (Asare et al., 2019).

These games often feature straightforward match procedures and rules. Mathematical games like Whot and Ludo show a strong interest in recreational mathematics (Moon & Ke, 2020). In most cases, playing or watching a game is more beneficial than learning arithmetic theory when it comes to understanding the fundamental mathematics of games. Mathematical games aid students in grasping fundamental concepts in mathematics to enhance their arithmetic skills in an engaging way (Rigelman & Lewis, 2023).

Gök (2020) stated that mathematics is entirely game, and games are mostly mathematics. Games share many of the same interactions found in the fundamental structure of mathematics, such as ratiocination, inference-making, and creative thought. In this context, it is convenient to incorporate games into teaching mathematics (Gök, 2020). Incorporating games into the mathematics curriculum is one technique to assist students in learning mathematics while still encouraging fun. The exciting world of games has a positive impact on students' attitudes towards mathematics, enthusiasm to learn, and participation in mathematics lessons. This approach makes learning settings more engaging for students (Moon & Ke, 2020).

Mathematical games can help maintain and sustain student interest, thus leading to good academic results (National Mathematical Centre, 2023). Furthermore, Aduwa (2021) claimed that games are primarily meant for fun and can foster competition and excitement. Games encourage winners to hold on to their lead, and losers to work toward overcoming their loss. According to the National Mathematical Centre (2023), one of the functions of mathematical games is to foster a positive attitude toward mathematics. Positive attitudes can develop because of games' informality and excitement. Exciting activities tend to be more popular with students. Numerous international studies have documented the benefits of using mathematical games in teaching and learning the subject. For example, in Washington D.C., Noah (2019) discovered that mathematical games improve students' comprehension and achievement in the subject. Also, in Pakistan, Shah et al. (2023) found that providing students with opportunities to play mathematical games and receive special instruction helped them reach higher achievement levels in the subject.

Also, the variable of gender was considered in this study. Research on gender and mathematics achievement has yielded various outcomes over time (Bajwa & Perry, 2021). However, current research challenges this assumption, emphasizing the role of social and cultural factors in affecting academic achievement. While some early studies revealed fundamental gender disparities, more recent analyses emphasize the influence of stereotypes and societal expectations in shaping students' self-perception and academic achievement (Maadi, 2022). The natural and cultural phenomenon known as "gender" identifies the different personality traits of men and women, and categorizes in all facets of life (Bajwa & Perry, 2021; Maadi, Mahadi & Alajimi, 2022).

Research on how a student's gender affects their academic achievement has not yielded any clear findings (Korkmazet al., 2023). Therefore, mathematics teachers should constantly incorporate encouragement and reinforcement to pique students' interest in mathematics, particularly female students. This study attempted to determine the effects of mathematical games on the achievement of mathematics in senior secondary school students, particularly in relation to gender in Abuja, Nigeria. The researchers considered the positive impact of mathematical games on mathematics achievement and the fact that many female students do not perform well in mathematics. Thus, this study investigated the impact of mathematical games on the mathematical achievement of senior secondary school students based on gender.

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## The Impact of Mathematical Games on Students' Mathematical Achievement

Deng et al. (2020) carried out a case study in Shanghai, China, focusing on using digital games for instruction in high school students' mathematics classes. The study's findings demonstrated that students' performance and engagement in mathematics were enhanced when they played digital games once a day for six days. Also, Go et al. (2022) examined how well computer games with mathematical themes support college students' basic mathematical skills. Researchers at a state university in the Philippines carried out a case study that examined undergraduate programs in information technology, mathematics education, and industrial engineering. According to the survey, playing digital games has been shown to help students' basic mathematical abilities. In the study of Sam-Kayode and Salman (2022), it was found that mathematical games help students perform better in mathematics classes and help to develop students' skills.

The study by Khateeb (2019) investigated the impact of mobile gaming on mathematical achievement in Zarqa, Jordan. Their sample consisted of sixty-six fourth graders divided into the experimental group ( $n = 34$ ) and the control group ( $n = 32$ ). The experimental group used educational mobile games, while the control group received instruction via the conventional method. The study found that using mobile games to provide students with instructional support in mathematics is an effective strategy.

Prior gender-specific research on how mathematical games affect students' achievement in mathematics in senior secondary school (Sam-Kayode & Salman, 2022) produced mixed results. Some suggest that games encourage participation and problem-solving skills, although methodological limitations and cultural differences remain unsolved. A more rigorous study is needed. This study investigates how mathematical games impact senior secondary school students' academic achievement, with a focus on gender inequalities. It seeks to fill a study gap on the efficacy of games in improving mathematics learning results, potentially leading to more inclusive and effective teaching.

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## Empirical Research on the Influence of Gender on Students' Mathematical Achievement

Prior studies on the impact of mathematical games on students' achievement in mathematics in senior secondary schools, taking gender into account, have

revealed a mixed picture. While some studies suggest that mathematical games improve general academic achievement, gender-specific outcomes differ. Several studies have found that interactive and engaging mathematical games benefit both male and female students by encouraging a deeper knowledge of mathematical ideas (Oliweh & Oyem, 2022). However, a subgroup of studies reveals that the degree of impact varies by gender, with some games being more effective for one gender than the other (Buser & Yuan, 2019). Overall, the convergence of previous studies highlights the necessity of taking gender dynamics into account when applying mathematical games in educational contexts, enabling a nuanced and inclusive approach to improving learning results.

Due to the contradictory nature of research findings on gender and mathematics, teachers continue to disagree notably about the impact of gender on students' achievement in this subject (Liang et al., 2020; Liu & Hwang, 2020; Akanmu & Adeniyi, 2021; Alsadoon et al., 2022). Singh et al. (2021) compared the average achievement ratings of male and female students who learned numbers using mobile games. The findings demonstrated that male students outperformed female students when taught with mobile gaming.

Ellison and Swanson (2023) used competition data to investigate the dynamics of the gender gap in high school mathematics achievement. By ninth grade, there is a noticeable gender difference, and it gets bigger with time. The gender gap is getting more comprehensive as a result of gender-related variations in dropout rates, as well as in the mean and variance of year-to-year improvement. According to the study, only some girls achieve significant enough gains to raise their rankings.

Buser and Yuan (2019) used regression discontinuity analysis to study the Dutch Mathematics Olympiad participants on the verge of moving on to the next round. For boys, they find a small and insignificant dropout effect of one percentage point, and for girls, a large and marginally significant dropout effect of eleven percentage points. We can use narrower windows and obtain more accurate estimates due to our significantly larger sample. The study discovered that girls are comparatively likelier to respond by quitting, but we also show that boys are greatly affected. The difference in effect between girls and boys in the competition is less significant than their point estimates for the Netherlands.

Oliweh and Oyem (2022) focused on the gender disparities in students' mathematics achievement in a selected secondary school in Delta State, Nigeria. The method of stratified random sampling was applied.

There were eight hundred secondary school students in the study population. To direct the investigation, a single research question and hypothesis were developed. Data were gathered and examined according to the study's objectives using the Statistical Package for the Social Sciences (SPSS). The hypotheses were tested at the significance level of 0.05. The mean variance of the research hypothesis was examined using the t-test analysis. The model's t-test p-value served as the basis for the decision. Levene's test for equality of variance supports the homogeneity of the variance. The hypothesis's findings demonstrate no difference between male and female students' math achievement.

Anokye-Poku and Ampadu (2020) conducted a study to investigate how girls and boys in Ghanaian junior high schools felt about mathematics and their success in the subject. A sample of 360 students was used in a descriptive survey design. Two tools were used to evaluate the student's performance: test results and a semi-structured questionnaire. The findings showed a statistically significant achievement gap, with male students outperforming female students in mathematics.

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### **Theoretical Framework for the Study**

Two theories – cognitive development and behavioral learning – provided the foundation for this study, which employed mathematical games. On the one hand, playing mathematical games while learning mathematics leads to cognitive development. Specifically, the study employed the cognitive development theory to examine how teachers can use mathematical games to assist learners in conceptualizing mathematics (Slavin et al., 2021). According to this developmental theory, student interaction on relevant tasks improves their grasp of essential ideas (Ekmekci & Serrano, 2022). Students gain a deeper understanding of the material they are studying when they interact with other students and have to explain and discuss each other's points of view (Slavin et al., 2021). According to the cognitive development theory, explaining the subject to someone else is one of the best ways to learn it. Playing mathematical games encourages more elaborate thinking and frequent explanations, improving understanding depth, reasoning quality, and long-term retention accuracy (Dimosthenous et al., 2021; Liang et al., 2020; Deng et al., 2020).

On the other hand, according to the theory of behavioral learning, students are more likely to commit to teamwork if teachers give them rewards for their participation (Morgan et al., 2019). Therefore, rewards for individuals and teams should be clear when employing

mathematical contests. Thus, from both of these theoretical perspectives, using mathematical games should result in better student learning.

As a result, this study demonstrated the two main theoretical stances on using mathematical games in education: the cognitive development theory, which emphasizes the effects on students, and the behavioral learning theory, which emphasizes the students' incentives to complete academic work, such as reward and goal structures (Slavin et al., 2021). These theories provide teachers with the framework to design learning environments catering to a classroom's diverse learning styles, interests, and abilities. Adopting the theories mentioned earlier suggests that teachers should break away from traditional methods of instruction and instead implement innovative strategies like audio, video, and field trips to give students more ways to absorb knowledge (Chiang et al., 2019). With the help of these techniques, students can succeed and learn at their own pace and style (Esperanza et al., 2023).

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### **Purpose of the Study**

The study aimed to examine how mathematical games affected senior secondary school students' gender-related academic performance in mathematics. The precise goals were to:

- Determine the impact of mathematical game use on students' mathematical achievement.
- Ascertain how gender affects students' mathematical achievement when utilizing mathematical games for teaching and learning.

### **Research Hypotheses**

The 0.05 level of significance formulates and tests the following null hypotheses:

- There is no significant difference in the mathematical achievement of students who were taught through mathematical games compared to their counterparts who were not.
- The effect of gender on students' mathematical achievement when they were taught with mathematical games is not statistically significant.

### **Significance of the Study**

The following groups will benefit from the results and recommendations of this study:

- Teachers will be provided with mathematical games to introduce new concepts and to engage students in learning mathematics.

- The government or the curriculum developers will organize regular training workshops and seminars for mathematics teachers so that their knowledge of mathematical game use in the classrooms can improve.
- Scholars contribute vital evidence and guide future educational practices by providing real evidence to existing knowledge. The report also identifies gaps in current knowledge and suggests directions for future research. This study contributes to the consolidation of existing knowledge, identifies areas requiring additional inquiry, and provides a thorough review for educators, researchers, and policymakers.
- It is vital to highlight that the outcomes of this study will also be used as a reference for other researchers who may want to perform similar studies in other parts of Nigeria.

### Limitations

The following limitations are pertinent to this study:

- The number of fourth graders randomly chosen from senior secondary school students in the Abuja Council Area of the Federal Capital Territory, Abuja, constitutes the study's sample size.
- The impact of mathematical games on senior secondary school students' academic advancement in mathematics is impacted by contextual limitations in Abuja, Nigeria, particularly in terms of gender. Sociocultural factors, educational infrastructure, and gender norms may all have an impact on the effectiveness of these activities, making it challenging to attain equitable results for male and female students.
- Tool and content validity are limited, due to the reliability of the instruments used in this study.

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## Methodology

### Research Design

This study used a quasi-experimental design. The two groups—one experimental group and one control group—were instructed in using mathematical games. While the control group received instruction using the standard methodology, the experimental group was exposed to treatments utilizing an instructional strategy based on mathematical games.

Pre-testing on the experimental and control groups determined the student's level of achievement, while the post-test after the treatment measured the change in learning outcomes in the groups. In this study, the mathematical game instructional strategy was the independent variable, the student's achievement represented the dependent variable, and gender (male and female)

was the moderator variable. Using a pre- and post-test, the researcher was interested in manipulating the independent variable (game) to observe its effect on the dependent variable (achievement in mathematics).

### Sample

The sample comprised 50 senior secondary school students in the fourth grade in the Abuja Council Area of Federal Capital Territory, Abuja, selected purposively from a population of 1,086 students. The fourth grade is the foundation class for senior secondary school classes. There were 30 males and 20 females in the sample. Three schools were selected for the investigation using simple random sampling. The schools selected for this study had (1) at least one teacher with a BSc (Ed.) Mathematics qualification, (2) teachers that taught mathematics, and (3) a considerable distance between the other schools. A coin toss was used in each selected school to assign intact classes to experimental and control groups randomly. The experimental group had 16 male and 10 female students, while the control group had 14 male and 10 female students.

### Data Collection

Before the experiment, two research assistants received training on conducting the experiments, which took place in one of the schools. The researcher explained the rules of the algebraic substitution game to the two research assistants and provided an outline of the algebraic expressions to be taught to learners. The research assistants taught the students about algebraic expressions over three weeks before the commencement of the experiment.

The study consisted of two stages: The preliminary stage and the implementation stage. During the preliminary stage, the experimental and the control groups were pre-tested using the Algebraic Achievement Test (AAT) before the teaching. The researcher created the 20 items that made up the AAT. Some examples of algebraic expressions are  $3x+2y-5$  or  $2a^2-4ab+b^2$ .

The study explores the impact of mathematical games on senior secondary school students' academic achievement, highlighting the complex interaction with gender dynamics. It suggests that gender-related issues, cultural barriers, and contextual factors, such as educational infrastructure and community attitudes, may influence outcomes. The purpose of the test was to ascertain the students' entry-level behavior.

During the implementation phase, the topic of algebraic expressions, scheduled for two weeks in the mathematics scheme of work and four periods per week on the school timetable, was taught to the experimental and

control groups. The researcher provided an example of algebraic expressions, along with guided practice. Variable and verbal expressions were as follows:

- (a) Examples of algebraic expressions: (i)  $x$  increased by 6 is  $x + 6$ ; (ii) the quotient of 18 and  $n$  is  $18/n$
- (b) Examples of verbal expressions: (i)  $x/2$  is half of  $x$ ; (ii)  $5n$  is five times a number, etc.

The students were taught algebraic expressions in a 40-minute lesson using eight periods throughout the two weeks. Following every lesson, students in the experimental groups solved an algebraic expression exercise. Students solved questions on algebraic expressions from the New General Mathematics book for senior secondary school (Murray et al., 2008).

Thereafter, the students were screened with the Algebraic Achievement Test (AAT), and those who scored a threshold of 40 or lower were assigned to one of four groups, three experimental and one control. Learners in the three experimental groups played the mathematical game.

The study aimed to examine the impact of a modified mathematics game on students' mathematics achievement in a varied classroom context. A modified version of "Snakes and Ladders" is used to improve mathematical learning by adding mathematical questions to each ladder or snake position on the board.

One group used a collaborative learning model, which promoted teamwork and cooperative problem solving. Students in this group explored the mathematical issues collectively, creating a supportive environment that promoted collective comprehension. Another group engaged in competitive gameplay, with individuals competing to answer challenges and to move up the board. This strategy attempted to create a sense of drive and urgency by imitating real-world problem-solving settings.

A third group utilized self-paced learning techniques, focusing on personalized learning and incorporating interactive technology to enhance understanding of mathematical concepts. The teacher supervised the groups to ensure that they followed the guidelines for solving algebraic expressions as described by Alsadoon et al. (2022), which are as follows:

- Each group of students had to work as a team and reach a decision by consensus.
- Every member of the group impacted the achievement of the others.

- Each assignment received a grade, and each group member received their group grade as their grade.
- Students could seek help from each other towards attaining a common goal.

For the post-test, the items in the pre-test (AAT) were re-arranged. The post-test was administered to all groups at the end of the mathematics game to assess what the students have learned. The tests were marked and graded.

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### Data Analysis

Descriptive and inferential statistics were employed to analyze the gathered data. The average and standard deviation display the pre-test and post-test results. Secondly, t-test statistics were used at a significance level of 0.05 to test the null hypotheses.

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### Quality measures

Three experts critically appraised the face and content validity of the instrument (AAT). The outcome of the appraisal of the items based on the experts' judgment gave a 0.85 index of logical validity.

The validated instrument (AAT) was trial tested to determine the reliability of the instruments, using 24 students who were part of the study's target population, but did not form part of the study. Also, the split-half reliability method establishes the instrument's internal consistency with a reliability coefficient of 0.84.

The instrument was considered adequate using psychometric item analysis, with an average of 0.56 as the difficulty index, 0.63 for the discrimination average index, and -0.13 as the distracter average index for the items.

The researchers implemented the following protocols to control for unrelated variables that could introduce bias into the study. The researcher put together a standardized training program for the teachers who worked as research assistants. The same research assistants managed the experimental and control groups. The test instruments were under the researcher's care, and research assistants helped only when asked by the teachers and when needed. The researcher assumed a supervisory role in averting the teachers' departures from the prescribed content of the lesson plans. The researcher obtained the pre-test and post-test that the instructors and students gave.



## Ethical considerations

Permission was granted by the ethical committee of the federal university, Oye Ekiti, to conduct this study. The researcher sought permission from the principals of the two selected schools. Consent forms were completed by students in these schools agreeing to participate in the study after discussing the students' consent, objectives, and activities. The researcher ensured that all works cited were referenced and paraphrased. After considering all ethical issues, a plagiarism check was conducted on the study to ensure high originality. The researcher also sought the support of two mathematics teachers in the selected secondary schools who served as the research assistants while administering the treatments to the experimental groups in their respective schools.

## Results

Descriptive statistics were first used to show the participants' biographical information, assess the remaining items' internal consistency, and determine the discriminant validity of the AAT with respect to mathematics. Second, the inferential statistics analysis focused on the test statistics of the variables, which included student achievement and gender. The results are shown based on the variations in the cross-variable averages when there were significant differences. It was determined through descriptive statistics that there were more male participants (60.0%; 30 out of 50) than female participants (40.0%; 20 out of 50).

### Research Question 1

What influence does teaching through mathematical games have on students' mathematics achievement?

Table 1 presents the experimental and control groups' mean gain scores for mathematical achievement. The pre-test mean scores for the experimental group ( $M = 41.47$ ,  $SD = 15.03$ ) and the control group ( $M = 41.38$ ,  $SD = 18.13$ ) differ slightly. The post-test mean scores, on the other hand, differed more between these groups ( $M = 61.12$ ,  $SD = 15.03$  and  $M = 45.38$ ,  $SD = 18.13$ , respectively). The control group's

mean gain was 4.00, while the experimental group's was 19.65. This result indicates that the experimental group performed better than the control group in terms of gain score.

### Research Question 2

How does teaching through mathematical games influence students' achievement in mathematics pertaining to gender?

Table 2 presents the descriptive statistics on the influence of gender on students' achievement when taught with mathematical games. The female students had higher mean achievement scores ( $M = 45.34$ ,  $SD = 21.72$ ) than the male students' ( $M = 40.02$ ,  $SD = 14.43$ ) for the pre-test before they were taught through mathematical games. However, the mean score between these two groups for the post-test ( $M = 76.35$ ,  $SD = 21.72$  and  $M = 56.42$ ,  $SD = 14.43$ , respectively) increased notably after they were taught through mathematical games. Thus, female students outperformed male students.

To establish whether the differences were significant, correlational statistics were employed using a t-test to measure the formulated null hypotheses at  $p \leq 0.05$ . A t-test is employed to determine if there's a significant difference between the means of two groups, indicating whether observed variations are statistically meaningful or just due to chance.

Table 1

*The Experimental and Control Groups' Mean Gain Scores for Mathematical Achievement*

Group	N	Pre-test Mean $X_1$	Post-test Mean $X_2$	Mean Gain Score $X_2 - X_1$	SD
Experimental	26	41.47	61.12	19.65	15.03
Control	24	41.38	45.38	4.00	18.13

Sources: Authors' computation from SPSS

Table 2

*Descriptive Statistics on the Influence of Gender on Students' Achievement when Taught with Mathematical Games*

Group	N	Pre-test Mean $X_1$	Post-test Mean $X_2$	SD
Male	30	40.02	56.42	14.43
Female	20	45.34	76.35	21.72

Sources: Authors' computation from SPSS

### Hypotheses 1

There is no significant difference in the mathematical achievement of students taught using mathematical games compared to their counterparts who were not.

Table 3 presents the independent t-test of the experimental and control groups. The difference between the experimental and control groups on the mathematical achievement of students who were taught through mathematical games. It is shown that the mathematical games of the experimental group had a significant influence on students' mathematics achievement among senior secondary school students [ $t(48) = 5.28, p=0.0019; p < .05$ ]. The results of the independent sample t-test are displayed in Table 3; the t-test value is 5.28, the degree of freedom is 48, and the p-value is 0.0019. The experimental group's mean is statistically higher than the control group's because the p-value is less than the 0.05 significance level. It is therefore asserted that there was a noteworthy distinction in the academic performance of senior school students who were taught mathematics through mathematical games and their counterparts in the control group. This demonstrated that the experimental group's usage of mathematical games significantly influenced their academic performance.

### Hypotheses 2

The effect of gender on students' mathematical achievement when they were taught with mathematical games is not statistically significant.

Based on Table 4, the result showed that gender had a significant influence on mathematical games among senior secondary school students [ $t(48) = 3.57, p=0.01; p > 0.05$ ]. Since the p-value is lower than the threshold of 0.05 significant coefficient, female students (mean = 31.01) made progress using mathematical games, compared to male students (mean = 16.40) on mathematics achievement. Therefore, it implies that female students perform better than male students after being exposed to mathematical games.

The mean gain scores of the students who participated in the math achievement tests are displayed in Table 4 according to their gender. When teaching mathematics through mathematical games, the mean gain score for female students was ( $x=31.01$ ), whereas the mean gain score for male students was ( $x=16.07$ ). Female students'

Table 3

*The independent t-test of the Experimental and Control Groups*

Group	Mean	N	Df	T	P
Experimental	19.65	26	48	5.28	0.0019
Control	4.00	24			

Sources: Authors' computation from SPSS

Table 4

*The independent t-test of the Experimental and Control Groups*

Group	N	Mean	Df	T	P
Male	30	16.40	48	3.57	0.01
Female	20	31.01			

Note: The correlation, denoted by p, is significant at the 0.05 probability level

mean gain scores were 14.94 higher when exposed to mathematical games than male students.

At the 0.05 level, both statistical tests assumed a significant correlation: the differences between the male and female variables were statistically significant. Consequently, female students made notable progress when taught mathematics using mathematical games.

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## Discussion and Conclusion

According to the study, teaching through mathematical games in senior secondary schools significantly increased students' mathematics achievement ( $M = 61.12, SD = 15.03$  and  $M = 45.38, SD = 18.13$ ). The experimental group's mean was ( $x= 19.65$ ), while the control group's mean was ( $x= 4.0$ ). The results show that the experimental group of students who played a mathematical game while learning the subject had higher mean scores than the control group of students who did not. Akanmu and Adeniyi (2021) investigated the impact of mathematical games on students' achievement in mathematics and discovered that it helps students perform better in the subject. As a result, compared to students taught without games, students taught with mathematical games produced noticeably better results in mathematics. Students could have achieved better when taught with mathematical games, as mathematical games illustrate theoretical and abstract concepts with concrete examples, which facilitate effective mathematics teaching and learning.

It is also evident from the study that female students outperformed male students, with the female students' mean value ( $x=31.01$ ) being higher than the male mean value ( $x=16.40$ ). The games were effective for male students in raising achievement and cultivating a positive attitude toward mathematics, despite their initial lack of enthusiasm. This was confirmed when they were encouraged to play. Mathematical games are valuable learning opportunities for both students and teachers, according to the teachers who oversaw their supervision. This finding corresponds with the findings of Yeh et al. (2019) and Ayebale, Habaasa, and Tweheyo (2020), who affirmed that female students exposed to mathematical games had a mean gain score higher than their male counterparts. Thus, gender significantly influenced students' achievement when mathematics was taught using mathematical games.

Given the identified factors, mathematics teachers should expose both genders to constructivist teaching methods, such as computer game instructional strategies (Noah, 2019), as mathematical games positively influence mathematics achievement. Students should learn by doing, taking an active role in building their understanding. Teachers should utilize mathematical games to help male and female students reach their maximum potential. It is, however, essential to note that female students benefit more from being exposed to mathematical games. Thus, teachers should expose female students to mathematical games that attract their interests.

As lack of interest in mathematics is a notable reason for student failure in the subject, mathematical games for teaching mathematics classes may hold a more significant promise of regaining students' achievement in mathematics, especially for female students.

This study examined how mathematical games affected the mathematical achievement of senior secondary school students in terms of gender in Abuja, Nigeria. According to the results, teaching through mathematical games significantly improved students' achievement in mathematics. Also, female students achieved higher scores than male students when taught through mathematical games.

The findings imply that teaching through mathematical games can enhance mathematics achievement and that mathematical games should, therefore, be used by teachers to introduce mathematics concepts to students at different levels. Mathematical games can create a

friendly atmosphere for student-centered teaching and learning to engage students in learning mathematics concepts. By organizing regular training workshops and seminars for mathematics teachers, teachers' knowledge of mathematical games can improve. School administrators should provide teachers with simple local games like Whot, Ludo games, and playing cards to facilitate the teaching and learning of specific topics in mathematics. However, using mathematical games in teaching is inadequate in accounting for continuous achievement disparity between males and females in mathematics across senior secondary schools in Abuja. Other factors such as the students' attitudes, self-efficacy, and ability levels should also be considered.

The study was limited to two senior secondary schools in an urban area in Nigeria. The authors suggest similar research in other contexts. Studies comparing urban and rural senior secondary school students' mathematics achievement when taught through mathematical games are also recommended. The authors further suggest using online mathematical games in longitudinal studies to follow students' progression in learning mathematics.

Parents may use the outcome of this study to provide educational games to their children at home to engage them in mathematics. Such games can provide opportunities for monitoring, advising, and encouraging their children toward positive achievement in mathematics.

Overall, including mathematical games into experimental investigations, together with a variety of gameplay methodologies, proved to be a novel and successful method for improving students' mathematics efficacy and achievement. Curriculum planners may find teaching with mathematical games beneficial when designing programs for mathematics teachers. The government may also appreciate and use the study's findings to improve and implement the general objectives of mathematics education as drawn up by the Federal Republic of Nigeria (FRN).

Teaching through mathematics games may make students more focused and willing to dedicate considerable time to engage in mathematics in the classroom. Teaching mathematics to senior secondary school students through games improves their academic achievement. Hence, teachers need to develop themselves by using mathematical games to enhance students' academic achievement in mathematics.

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### **Informed Consent**

The authors have obtained informed consent from all participants.

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### **Conflict of Interest**

The authors declare that there is no conflict of interest.