

Efficacy of Manipulative Games on Lower Basic Pupils' Academic Achievement in Mathematics in Plateau State, Nigeria

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Article Information	Abstract
Received: 21 May 2024	<i>Manipulative games are designed to enhance experiential learning of Mathematics for kids in primary education. The subpar performance of primary school students in Mathematics has been attributed to the use of a teacher-centered educational method. This study investigated the efficacy of manipulative games on the arithmetic performance of lower basic pupils in Plateau State. This study utilized a 2X2X2 pre-test, post-test, control group non-equivalent quasi-experimental design. The study's population focus included all elementary schools with a solitary pupil, encompassing both public and private institutions. A multistage sampling method was utilized to choose a sample of 106 pupils. The experimental groups were administered the treatment package encompassing four mathematical themes. The experimental and control groups underwent pre-test and post-test evaluations using a validated Mathematics Achievement Test (MAT) that has a reliability coefficient of 0.81. The presented hypotheses were evaluated using Analysis of Covariance (ANCOVA) with a significance level of 0.05. The study's results demonstrated a significant effect of manipulative games on the academic performance of lower basic learners in Mathematics in Plateau State. The study concluded that manipulative games affect the mathematics ability of primary school kids, regardless of gender or</i>
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kind of institution. The study recommended the incorporation of manipulative games into the basic school curriculum to enhance the teaching and learning of Mathematics.

Keywords: *Manipulative games, School type, Mathematics achievement, Lower Basic Pupils*

Introduction

Mathematics is an indispensable aspect of human endeavour that characterizes every facet of human life. People engage in mathematical activities every now and then whether knowingly or unknowingly. It is an organised and systematic way of reasoning that sharpens the human mind to make him capable of solving both simple and complex problems of every day regardless of age, class, or any demographics. Mathematics is an everyday experience for both young and old.

Majority of man's daily activities revolve around basic principles of Arithmetic processes (Gyang, et al. 2018). Tanswell (2024) observed mathematics as one of the greatest accomplishments of mankind. Mathematics has facilitated the progress of science, technology, engineering, commerce, and governance by enhancing human cognitive abilities. The discipline of mathematics inherently fosters mathematical reasoning, creativity, abstract or spatial thinking, problem-solving abilities, critical thinking, and effective communication skills. People need to understand fundamental mathematics in order to properly participate in society. People who are unable to use mathematical reasoning are excluded from many areas of human endeavour. They are deprived of opportunities due to their inability to perform basic principles in mathematics (Tanswell, 2024).

Despite its importance, mathematics has historically been a source of concern for many children (Adu & Duku, 2021; Isah & Hamza, 2023). Iwuanyaunwu (2021) stated that one regrettable part about mathematics is that despite everyone's recognition of it for what it is, not much is being done to address the challenges pupils encounter learning it. Iwuanyaunwu (2021) further stated that before most pupils begin studying mathematics, even in its most basic form, they have several preconceptions that work against their interest in the subject. Some of these prejudices are innate, while others are brought on by outside factors like ineffective teaching techniques.

Pupils who perform poorly in school may become dissatisfied if their teachers are unable to address their perceived variety of learning challenges. Kumar (2021) claimed that while mathematics is crucial to national development, learning it in Nigerian schools is hindered by low pupils' accomplishment. Methodology, instructional materials, inadequate preparation of pupils from preschool, unprepared teachers, and unfavourable learning environment may all contribute to this unpleasant scenario in mathematics.

Data at the Local Government Education Authority (LGEA) of Jos North LGA shows that out of the 16,923 pupils that sat for common entrance examination in 2021, only 32 % passed mathematics at credit level while in Jos South Local Government Education Authority (LGEA), out of the 15,657 that sat for the examination, only 34% of the pupils passed at credit level (Plateau State Ministry of Education, 2022). This low performance of the pupils can be attributed to ineffective teaching strategies and a dearth of teaching resources (Malaki, 2021).

Other possible factors include pupils' lack of interest in mathematics and the workload of math teachers (Bah, 2021; Maney & Bunto, 2024).

Manipulative games are educational games or activities that incorporate manipulative materials as a component. They are structured activities and promote social interaction that involve group play. Examples are geometric solids, base ten blocks, number liners, card games, money games etc. According to Monte (2021), the phrase "manipulative" is the concrete model putting the mathematical concepts together, addressing various emotions and that can be touched and moved by the pupil. Bright, Welcome and Arthur (2024) took the decision to employ technology and manipulative materials in mathematics and to use them as resources to enhance mathematics instruction.

Puzzles and other games that appeal to one's interest or entertainment can be considered mathematical games. These games offer entertainment and fun. They encourage critical thinking in mathematics and foster excitement and friendly rivalry. Games including mathematics are described as fun social activities with rules, aims, and goals by Aremu and Adebago (2016). When playing a math game, two or more participants collaborate to solve a specified mathematical problem. Both losers and victors receive reinforcement from manipulative games. For example, the winners will work to keep their advantage while the losers will try to bounce back from their setbacks. Games help children decompress, alleviate boredom, and create a learning atmosphere where they may improve their skills and learn new things (Omeodu & Fredrick, 2019). Games and mathematics have rules that are similar since they both involve practice, drill, and real-world applications.

This study examined two mathematical games which were roll the dice and dominos. These games share the same characteristics in the sense that they are both manipulative games. They require at least two children to play them. Roll the dice game require pupils to roll their dice and either sum up the numbers or minus them. But first, pupils are expected to write out the numbers in their books before they can use manipulative materials such as stones, counters etc to compute their answers. The dominos game is a card game that contains different problems that children were expected to solve. A pupil first shuffles the cards and another child picks any card at random and solve the problem written on it. The pupils also make use of manipulative materials to help them solve the problem. While it is your turn to play, the other children will be there to confirm whether you got the right answer or not.

It is acknowledged that children possess a profound inclination towards games. They exhibit a profound enthusiasm for engaging in games. A research investigation into the effects of the concrete manipulative method on students' attitudes, retention, and performance in geometry within Benue State, Nigeria, was carried out by Akaazua et al. (2017). The findings indicated a noteworthy distinction between students who engaged with geometry through the concrete manipulative approach and those who were instructed via the conventional lecture method. The application of manipulative tools within the mathematics classroom significantly influences students' involvement, engagement, and overall academic achievement.

Furthermore, Ochiagha et al. (2021) examined the influence of the game of set on the academic performance of adult learners in basic arithmetic. A substantial disparity was found between the average achievement scores of the two groups. The data indicates that adult students instructed through the game of set surpassed their counterparts taught via traditional methods on the fundamental arithmetic accomplishment test. Kwabe, Hannatu, and Waviche (2024) assessed the impact of game-based teaching methodologies on the academic performance of

primary school students in fundamental science and technology in Adamawa State, Nigeria. Their research shown that simulation gaming environments serve as a significant pedagogical method that affects students' proficiency in and perceptions of fundamental science and technology. A significant achievement disparity existed between the control and experimental groups of students.

Gender differences in cognition and brain lateralization have been utilized to elucidate variations in mathematics teaching and learning (Ajai & Imoko, 2015). Oluyemo et al. (2020) indicate that girls often experience marginalization and inferior treatment in mathematics classes. Educators assert that female students' success in arithmetic is more reliant on rote memorization, diligence, and effort rather than on innate ability, adaptability, and willingness to take risks, which are characteristics associated with male students' learning approaches. Eriksson (2020) argues that male and female students possess distinct worldviews. They occupy diverse social positions. Their diverse learning styles and methods of perceiving and processing reality constitute the second aspect. The researchers indicated that males generally excel in arithmetic due to the alignment of mathematics classroom discourse with their preferred learning styles. Okpe, Ezugorie, and Aneke (2022) argue that the perception of mathematics as a male domain may discourage girls and exacerbate the gender gap in mathematics achievement.

A study on the impact of math games on secondary school students' attitudes toward arithmetic was conducted by Ihendinehu (2017). Gender-specific analysis reveals that boys were more enthusiastic about the mathematics games than girls. Some of the boys proclaimed that games had to be included in every mathematics course because they effectively eliminate the monotony and dread frequently connected with math. When female students were invited to join, they attested to the effectiveness of the games in boosting achievement and cultivating a good attitude toward mathematics, despite their initial lack of enthusiasm for the games. The teachers who oversaw the math games attested to the fact that the lessons children and teachers may gain from math games are beneficial. The research conducted by Ajai and Imoko (2015) on gender disparities in mathematics achievement and retention indicated that there were no significant differences in scores between male and female students taught algebra through games, illustrating that both genders are equally capable of competing and collaborating in mathematics.

Conversely, other research studies have examined the impact of different school kinds on students' mathematics achievement (Akinsola & Frederick-Jonah, 2014; Azuka, 2014; David et al., 2020; Kisigot, Ogula & Munyua, 2022; Mafugu, 2024). In an ex-post facto design research on school type and students' academic achievement in social studies among junior secondary school students conducted by Okon and Archibong (2015), the findings indicated that students in private secondary schools surpassed their public school counterparts in the junior secondary institutionalized examination in social studies. Reports indicated that private schools had teachers who were qualified and proficient in several mathematical disciplines, whereas public schools often had teachers instructing subjects beyond their areas of expertise.

A study by Aransi (2020) revealed no significant variation in pupils' study habits based on school type and gender factors. He asserted that students' exhibition of specific study habits and attitudes, including effective time management for academic tasks, tendencies toward procrastination, concentration levels, memory capacity, utilization of study aids and note-taking proficiency, test-taking strategies, and test anxiety, were correlated with the type of school attended and the characteristics of the respective gender.

Almost all of human activity involves mathematics, particularly in the current era of science and technology. Pupils encounter mathematics in their daily activities, whereas, pupils' low academic performance in the subject has been caused by their poor understanding of mathematical concepts and inadequate mastery of mathematical skills (Azuka, 2014; Gyang et al., 2018; Adu & Duku, 2021). Low learning outcome have permeated mathematics in Plateau State at the lower basic level which could be due to the inappropriate methodology employed by the teachers. If mathematics will continue to be the base for science and technology, teaching the subject must be taken very seriously by the teachers at the basic level. It is against this backdrop that the researcher found it necessary to find out the efficacy of manipulative games on lower basic pupils' academic achievement in mathematics in Plateau State. Also, the study proposes to find out how gender and school type as moderating variables affect the pupils' achievement in mathematics.

The purpose of this study was to investigate the efficacy of manipulative materials and games on lower basic pupil's academic achievement in mathematics in Plateau State. Specifically, the study seeks to:

- i. examine the effectiveness of manipulative games on the academic performance of lower basic learners in mathematics within Plateau State.
- ii. determine the interaction effect of manipulative games on the academic achievement in mathematics of lower basic learners in Plateau State, categorized by gender.
- iii. assess the interactive effects of manipulative games on the academic achievement in mathematics of lower basic learners in Plateau State, categorized by school type.
- iv. investigate the interaction effects of manipulative games, gender, and school type on the academic achievement in mathematics of lower basic learners in Plateau State.

In order to achieve the above stated purpose of the study, the following research hypotheses were generated and tested:

H₀₁: There is no significant effect of treatment on lower basic pupils' academic achievement in mathematics in Plateau State.

H₀₂: There is no significant interaction effect of treatment and gender on lower basic pupils' academic achievement in mathematics in Plateau State.

H₀₃: There is no significant interaction effect of treatment and school type on lower basic pupils' academic achievement in mathematics in Plateau State.

H₀₄: There is no significant interaction effect of treatment, gender, and school type on lower basic pupils' academic achievement in mathematics in Plateau State.

Method

This study employed a non-equivalent quasi-experimental design featuring pre-test and post-test control groups. A 2x2x2 factorial design was employed for the research. The initial two phases comprised the experimental group (manipulative games) and the control group (traditional approach). The second factorial level was defined by gender (male and female), while the third level was specified by school type (public and private). This design enabled the experimental groups to receive treatment through manipulative games, whereas the control

groups were instructed using traditional methods. Furthermore, both the control and experimental groups underwent pre-test and post-test assessments, as illustrated in Table 1.

Table 1: Factorial Design for Manipulative Games and Control Group

Groups	Gender	School Type	Pretest	Treatment	Post-test
Experimental	M/F	Private/Public	O ₁	X	O ₂
Control	M/F	Private/Public	O ₁		O ₂

O₁ X O₂ Experimental Groups

O₁ and O₂ Control Groups

--- Non-equivalent

O₁ and O₁ were represented as the pre-test for the two groups while

O₂ and O₂ represent the post-test for the groups in that order.

The study population comprised 254,947 lower basic pupils from 3,522 primary schools in Plateau State, Nigeria, including 1,174 public and 2,348 private institutions (Plateau State Ministry of Education, 2022). The target population included all primary one pupils in the State. The sample size included 106 pupils. The research utilized a multi-stage sampling technique to select participants. Initially, a purposive sampling technique was employed to select four primary schools with both male and female pupils within the State. Subsequently, a stratified random sampling technique was utilized to select two public schools and two private schools. The schools were randomly allocated to treatment and control groups. Three instruments designed by researchers were utilized for data collection in the study. The instruments utilized comprised the Mathematics Achievement Test (MAT), the Instructional Guide for Manipulative Games (IGMG), and the Instructional Guide for Conventional Teaching Method (IGCTM). The instruments' validity was determined through expert judgment, while the reliability of the Mathematics Achievement Test (MAT) was assessed using parallel form reliability, yielding a value of 0.81. The researcher implemented the treatment package for both the experimental and control groups. The duration of the study was six weeks. The collected data were analyzed using inferential statistics. The research hypotheses were evaluated using Analysis of Covariance (ANCOVA) at a significance level of 0.05.

Results and Discussion

The study's results were presented in accordance with the established hypotheses. *Research Hypothesis One:* Treatment has no substantial impact on the academic achievement in Mathematics of lower basic learners in Plateau State, Nigeria.

Table 2: Summary of ANCOVA showing the effect of treatment on lower basic pupils' academic achievement in Mathematics in Plateau State

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Remark
Corrected Model	18296.80 ^a	8	2287.10	8.27	0.00	
Intercept	6025.19	1	6025.19	21.79	0.00	
Pretest	569.04	1	569.04	2.05	0.15	

Treatment*	15989.74	1	15989.74	57.84	0.00	Significant
Error	26815.45	97	276.44			
Total	603000.00	106				
Corrected Total	45112.26	105				

Table 2 presents an analysis of the impact of treatment (manipulative games) on the academic achievement in mathematics of lower basic pupils. The analysis indicates a significant impact of the treatment on the academic achievement in mathematics of lower basic pupils ($F(1; 97) = 57.840$; $p < 0.05$). The null hypothesis is rejected due to a p-value of 0.00, which is below the threshold of 0.05. The treatment involving manipulative games significantly impacted the academic achievement of lower basic pupils in mathematics.

The treatment's notable impact on the pupils can be ascribed to the treatment package and the efficacy of manipulative games in enhancing comprehension of mathematical concepts and fostering a positive attitude toward mathematics. This finding aligns with the research of David et al. (2015) and Akaazua et al. (2017), who conducted a similar study and found that manipulative games improved pupils' academic performance in mathematics. Furthermore, this aligns with Kimble (2020), who discovered that the use of manipulatives in mathematics classes increases student activity, enhances motivation for learning, and fosters a positive attitude towards mathematics lessons. The prepared teaching materials enhance students' mathematics achievement, as manipulative games serve to concretize abstract mathematical concepts.

Research Hypothesis Two: There is no significant interaction effect of treatment and gender on lower basic pupils' academic achievement in Mathematics in Plateau State.

Table 3: Summary of ANCOVA showing the interaction effect of treatment and gender on lower basic pupils' academic achievement in Mathematics in Plateau State

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Remark
Corrected Model	18296.80 ^a	8	2287.10	8.27	0.00	
Intercept	6025.19	1	6025.19	21.79	0.00	
Pretest	569.04	1	569.04	2.05	0.15	
Treatment*	15989.74	1	15989.74	57.84	0.00	Significant
Treatment * Gender	73.67	1	73.67	0.26	0.61	Not Significant
Error	26815.45	97	276.44			
Total	603000.00	106				
Corrected Total	45112.26	105				

Also, in the table 3, it was revealed that the F-value of 0.26 is not significant at 0.05 alpha level ($F(1; 97) = 0.26$; $p > 0.05$). This showed that the stated null hypothesis is not rejected. It implies that there is no significant interaction effect of treatment and gender on lower basic pupils' academic achievement in Mathematics.

This finding that revealed no significant interaction effect of treatment and gender on lower basic pupils' academic achievement in Mathematics in Plateau State could be as a result of the equal opportunity given to the participants regardless of their gender and their equal participation in the activities. It could also be as a result of the common interest and shared aspirations to succeed. This finding supported the findings of Ajai and Imoko (2015), Omeodu and Fredrick (2019) who conducted similar studies and discovered that when given the opportunity to actively participate in manipulative game activities, the problem of gender parity will be solved as both male and female participants improved significantly in their post test scores. However, the finding is incongruous with Cockett and Kilgour (2015) and Ihendinehu (2017) who discovered that boys were more enthusiastic than girls about manipulative games thereby enabling them to earn higher scores.

Research Hypothesis Three: There is no significant interaction effect of treatment and school type on lower basic pupils' academic achievement in Mathematics in Plateau State.

Table 4: Summary of ANCOVA showing the interaction effect of treatment and school type on lower basic pupils' academic achievement in Mathematics in Plateau State.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Remark
Corrected Model	18296.80 ^a	8	2287.10	8.27	0.00	
Intercept	6025.19	1	6025.19	21.79	0.00	
Pretest	569.04	1	569.04	2.05	0.15	
Treatment*	15989.74	1	15989.74	57.84	0.00	Significant
Treatment * Schl type	625.75	1	625.75	2.26	0.14	Not Significant
Error	26815.45	97	276.44			
Total	603000.00	106				
Corrected Total	45112.26	105				

Furthermore, the findings presented in table 4 demonstrate that the F-value of 2.26 does not reach significance at the 0.05 alpha level ($F(1; 97) = 2.26; p > 0.05$). Therefore, the null hypothesis, which posits that there is no significant interaction effect of treatment and school type on the academic achievement of lower basic pupils in Mathematics in Plateau State, remains accepted. The findings suggest that there is no notable interaction effect between treatment and school type on the academic achievement in mathematics of lower basic pupils.

This observation may stem from the shared adoption of a common mathematics curriculum by both public and private educational institutions. Consequently, there was no notable interaction effect between treatment and school type on the mathematics achievement of lower basic pupils. This aligns with a study conducted by Aransi (2020), which demonstrated that the empirical findings indicated no significant difference in student achievement when categorized by school type. This discovery contrasts with the conclusions drawn by Okon and Achibong (2015), as well as Kisigot, Ogula, and Munyua (2022), who indicated that individuals from private educational institutions exhibited superior performance compared to those in public schools.

Research Hypothesis Four: There is no significant interaction effect of treatment, gender and school type on lower basic pupils' academic achievement in Mathematics in Plateau State.

Table 5: Summary of ANCOVA showing the interaction effect of treatment, gender and school type on lower basic pupils' academic achievement in Mathematics in Plateau State.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Remark
Corrected Model	18296.80 ^a	8	2287.10	8.27	0.00	
Intercept	6025.19	1	6025.19	21.79	0.00	
Pretest	569.04	1	569.04	2.05	0.15	
Treatment*	15989.74	1	15989.74	57.84	0.00	Significant
Treatment * Gender *Schl Type	173.09	1	173.09	0.62	0.43	Not significant
Error	26815.45	97	276.44			
Total	603000.00	106				
Corrected Total	45112.26	105				

Furthermore, the result in table 5 indicated that the F-value of 0.62 is not significant at 0.05 alpha level ($F_{(1; 97)} = 0.62$; $p > 0.05$). This revealed that the stated null hypothesis which states that there is no significant interaction effect of treatment, gender and school type on lower basic pupils' academic achievement in Mathematics in Plateau State is not rejected. It implies that there is no significant interaction effect of treatment, gender and school type on the lower basic pupils' academic achievement in mathematics. In addition, this result could be attributed to the equal opportunity given to the pupils during the treatment and also, due to increase awareness that both boys and girls could be treated the same and could be whatever they choose to be regardless of their gender. This finding differ from Oluyemo et. al. (2020) who reported that parents and teachers shared opinion that regardless of the education of girl child, their ability cannot compete favourably with their male counterparts.

Conclusion

It was found that manipulative games had a significant effect on the academic achievement of the pupils in mathematics. This indicate that the use of manipulative games in mathematics instruction has a positive impact on pupils' performance in mathematics. Pupils who learned mathematical concepts through interactive, manipulative games demonstrated improved problem-solving skills and a deeper comprehension of abstract mathematical concepts compared to those who received traditional instruction. Manipulative games could enhance pupils' motivation and interest in learning mathematics, thereby reducing anxiety and fostering a more positive attitude toward learning in the subject. It was also discovered that pupils, regardless of their gender and school type performed better when they were taught using mathematical games. Therefore, teachers are encouraged to integrate game-based learning into classroom instructions to create a more engaging and interactive classroom environment, particularly for challenging mathematical concepts.

Recommendations

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

1. Teachers in lower basic schools should adopt the use of manipulative games that are developmentally appropriate in teaching mathematics to the pupils so as to enhance their academic achievement as revealed by the findings of this study.
2. Teachers in the lower basic schools should give equal treatment to both male and female pupils in mathematical games to enable them to achieve higher academic goals regardless of their gender as revealed by the study.
3. Government and private school owners should prioritise mathematical game strategy in teaching mathematics to lower basic pupils so as to increase their academic achievement regardless of their school type as it was revealed by the findings of the study.
4. Curriculum planners should incorporate mathematical games into the curriculum that it may serve as a better alternative instructional strategy and a reminder to the teachers and administrators.

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