Faculty of Natural and Applied Sciences Journal of Mathematics and Science Education
Print ISSN: 2814-0885 e-ISSN: 2814-0931
www.fnasjournals.com
Volume 6; Issue 2; March 2025; Page No. 130-136.

Effect of Virtual Manipulatives on Junior Secondary School Students' Interest and Achievement in Geometry

Ejiofor-Chima, N.A.
Department of Science Education, Federal University Otuoke. Bayelsa State, Nigeria

Corresponding author email: ngoziae@fuotuoke.edu.ng

Abstract
The research investigated the impact of virtual manipulatives on the interest and academic performance of junior secondary school pupils in geometry. The research used a quasi-experimental approach, informed by two research questions and two hypotheses. The study population consists of 1,375 JSS3 pupils. A sample of 120 intact JSS3 pupils was used. The instruments used for data collection were the Geometry Interest Inventory (GII) and the Geometry Achievement Test (GAT), both of which received validation from specialists in measurement and assessment. A reliability index of 0.76 for GII was determined using Cronbach's alpha, whereas GAT exhibited an index coefficient of 0.81, estimated by Kuder-Richardson (KR-20). Descriptive statistics, including mean and standard deviation, were used to address research issues, while hypotheses were evaluated using ANCOVA at a significance level of 0.05. ANCOVA was used to account for individual variations in the covariate attributable to the intact class. The study's results indicated that the use of virtual manipulatives in geometry instruction enhances students' interest in mathematics and elevates their academic performance. It was proposed that mathematics instructors use virtual manipulatives to enhance student engagement and increase academic performance in mathematics.

Keywords: Virtual Manipulatives, Geometry Education, Student Interest, Student Achievement, Mathematics Education

Introduction

Science, technology, engineering, and mathematics are the bedrock of any nation's progress. Sound understanding in the study of science and technology, with its knowledge based on mathematical concepts, is essential for every country to achieve sustained national progress (Ezekiel & Amino, 2018). At now, a country's degree of development is determined by its rate of scientific and technical advancement. Mathematical concepts are the basis of scientific understanding. Because of this, mathematics became the primary foundational field for all branches of science. The federal government of Nigeria mandated mathematics as a credit-bearing subject at all school levels in 2004 due to the subject's critical relevance. Mathematical reasoning, pattern recognition, and structure, as well as abstraction and application, were defined by the National Council of Teachers of Mathematics. It encompasses a wide range of disciplines, from science and engineering to economics and finance, and it describes, analyzes, and solves issues using mathematical models, theories, and methods. According to Elisha (2022), mathematics is a universally acknowledged vital science with broad practical applications. Mathematics is essential for every scientific inquiry or development-oriented national endeavor, according to Adebule and Ayoola (2015). Every living thing and every nation's progress depend on mathematics. This is due to the fact that mathematics is an integral part of our daily lives, whether we are aware of it or not. Instilling computational abilities and a firm grounding in children via mathematics education places the subject in a pivotal position within the school curriculum (Attah, 2016). To the extent that it is relevant to the work at hand, it serves to cultivate in pupils both the desire and the capacity to solve issues accurately. Students' problem-solving skills are enhanced by mathematics since it helps them spot difficulties and use relevant mathematical knowledge. The capacity to think abstractly, critically, and logically is fostered in pupils. It inspires and motivates pupils to think creatively while giving them the groundwork for future academic success. (Ogundipe, 2015).

The dismal state of pupils' mathematical performance throughout the last many decades and into the present day demands immediate action. With a percentage pass in mathematics of 49.98—well below 50%—the 2018 annual results of the West African test Council painted an uninspiring image of pupils' mathematical

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performance on the senior school certificate test. Mathematical performance on the Secondary School Certificate of Education (SSCE) test has been inconsistent between 2019 and 2024, necessitating ongoing efforts to raise standards in the field. Students' low math scores clearly point to systemic issues in our educational system and need prompt action. This is due to the fact that all scientific subjects rely on mathematical concepts for their knowledge, therefore, a student who struggles in mathematics would also struggle in other scientific subjects. The problem here is that no Nigerian university will admit a student who did not get a passing grade in mathematics on the Senior Secondary Certificate of Education (SSCE). Universities in Nigeria are vital for the country's economic and social development because they produce a workforce that is adaptable, talented, and resourceful. (Musa & Dauda., 2014).

Consequently, several scholars have proposed various factors related to this matter. It has been shown that teaching approaches like lecturing and rote memorization hinder students' motivation and accomplishment in mathematics, which is the main reason why pupils do poorly on the subject (Okereke, 2015). Students' engagement with and success in mathematics classes are directly impacted by the methods and approaches used by their teachers. Since mathematical concepts are inherently abstract, effective methods of instruction must pique students' attention while simultaneously making them more easily learn and apply the material (Adebayo, 2013). Additionally, research by Ogbonanya (2012) found that many math instructors do not have the proper training or expertise, which in turn causes their pupils to be uninterested in and underachieve in the subject. Reason being, you can only impart knowledge that you have yourself. Consequently, the instructor imparts to the pupils the information that he or she has, which, as a seasoned educator, ought to be able to pique their interest. According to Ikeji (2013), a significant number of secondary schools in Nigeria do not have sufficient learning resources, specifically instructional materials for mathematics. This might have a negative impact on students' motivation and performance in math classes. Consequently, it follows that students' disinterest and low performance in mathematics are caused by teachers' lack of qualification and experience, their failure to employ acceptable teaching methods, and the usage of correct learning materials throughout the learning process.

Mathematical topics may be better understood via the use of virtual manipulatives, which are interactive online tools and resources. According to Ukeagbu et al. (2017), a virtual manipulator is a web-based visual depiction of a dynamic object that allows users to engage with it and build their mathematical knowledge. Pattern blocks, base ten blocks, geometric solids, tangrams, and geoboards are examples of physical manipulatives; virtual manipulatives are representations of them in a graphical format. As a result of the interactive nature of virtual manipulatives, students are able to practice problem-solving with a greater grasp of mathematical concepts through the development of relational thinking and the ability to generalize mathematical ideas (Gadanidis, 2011). By letting students investigate and comprehend intricate connections, virtual manipulatives also provide dynamic representations of mathematical ideas (Borba, 2011). Because students may use the virtual objects or photos wherever and whenever they choose, virtual manipulatives provide students more agency and agency in their own learning (Reimer, 2004). Through active participation in online activities and the provision of feedback for both forward and backward correction, the use of virtual manipulatives increases students' motivation to study mathematics, which in turn improves their academic performance in the subject.

The study of three-dimensional space, including dimensions, form, and location, is known as geometry. Geometry is the study of shapes and their relationships in two and three dimensions using the properties of lines, angles, and planes (Leinwarnd, 2014). While traditional geometry classrooms have plenty of real-life manipulatives to work with, students may also benefit from using digital representations of geometrical ideas when resources are few. Borba (2011) argues that students may better grasp geometric ideas and their complicated linkages via the use of virtual manipulatives, which provide an interactive and dynamic picture of the subject. The purpose of this research is to determine whether or not junior high geometry classes may benefit from the use of virtual manipulatives.

Statement of Problem

The abstract nature of mathematics necessitates the use of logic, critical thinking, and problem solving skills. Students' disinterest in and subsequent low performance in mathematics is said to stem from the subject's inherent difficulty as well as from the methodological stance taken by certain educators. Teachers' pedagogical choices are to blame for students' disinterest and low performance in mathematics, according to Okereke (2015). Students' low math scores are due to a number of issues, including teachers' ignorance of the subject, students' beliefs that geometrical proofs are hard to understand, class size, instructional materials, and teacher quality and quantity (Gunjan, 2016). Methods like engaging students' interests and providing them with opportunities to apply what they've learned are essential for mathematics educators seeking to demystify the topic and make it more accessible to their pupils. Virtual manipulatives will captivate students and involve them in the learning process since we live in a technology era when kids are more engaged and interested in manipulating technological devices. Geometry is a subfield of mathematics that focuses on three-dimensional forms and makes use of manipulatives to help students grasp abstract ideas. Consequently, when physical manipulatives are unavailable or insufficient, the use of digital alternatives becomes essential. Students will have a better grasp of geometric concepts when they employ virtual manipulatives, which have three main advantages: interaction, dynamic representation, and adaptability. This research aims to shed light on the impact of virtual manipulatives on the interest and success of junior secondary school pupils in geometry.

Purpose of the study

The purpose of the study is to investigate the effect of virtual manipulatives on Junior Secondary School three (JSS3) students' interest and achievement in geometry in Rivers state. Specifically, the study seeks to;

1. Find out Junior Secondary School three (JSS3) students' interest in geometry when taught geometry using virtual manipulatives.
2. Examine the Junior Secondary School three (JSS3) students' achievement in geometry when taught using virtual manipulatives.

Research questions

The following research questions were raised to guide the study:

1. What is the interest rate of JSS3 students taught geometry using virtual manipulatives and those taught using the lecture method?
2. What is the achievement mean score of JSS3 students taught geometry using virtual manipulatives and those taught using the lecture method?

Hypotheses

The following hypotheses were formulated and tested at 0.05 significance level

1. There is no significant difference between the interest mean rating of JSS3 students taught geometry using virtual manipulation and those taught using the lecture method.
2. There is no significant difference between the mean scores of JSS3 students taught geometry using virtual manipulation and those taught using the lecture method.

Methodology

The research was conducted using a quasi-experimental method, using classes in their original form. Instead of randomly assigning people to a treatment or control group, the researcher used a pretest-posttest design. Source: Rivers State Universal Basic Education Board yearly school census. The population of the study consists of 1,375 JSS3 pupils from the 2022/2023 academic session in the Port Harcourt local government region of Rivers State. A total of 120 students from each of the four secondary schools included in the research were recruited from their respective JSS3 classrooms. To find the schools that had fully operational technology or information labs, researchers utilized a purposeful sampling strategy; to find the schools without, they used a simple random selection method. As a control group, we used two schools without an information and communication technology lab, and as an experimental group, we utilized two schools having one. The experimental group consisted of 62 pupils, whereas the control group included 58. The research made use of two tools. An assessment tool for measuring interest in geometry and the ability to demonstrate mastery of the subject. To find out how the students felt about the idea on a deeper level, we used the GII. There are two parts to GII. Section B inquired about respondents' enthusiasm for geometry, a subfield of mathematics, whereas Section A requested demographic details. Twenty items make up the GII, and answer types range from "Strongly Agree" (SA) to "Agree" (A), "Disagree" (D), and "Strongly Disagree" (SD). Using previous questions from the Basic Education Certificate Examination (BECE) and the Junior Secondary School Certificate Examination (JSSCE), the instrument known as the Geometric Achievement Test (GAT) had ten multiple-choice questions on geometry. Measurement and evaluation specialists and mathematics education professors checked the tests. Twenty non-participants from Junior Secondary School 3 (JSS3) who share demographic traits with the general public were chosen at random from a pilot survey to check the instrument's reliability. The reliability of GII was determined using Cronbach's alpha, yielding an index of 0.76; on the other hand, the reliability of GAT was determined using Kuder-Richardson (KR-20), yielding a coefficient of 0.81.

Prior to the start of the two-week course, students in both groups were given a Pre-GAT and GII. The results were compiled. The control group was taught geometry (Pythagorean theory and right angle triangle) using a well-designed lesson plan for two weeks in a lecture-based setting with the help of two mathematics instructors. For two weeks, the experimental group was instructed by two virtual manipulatives-trained instructors via the

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APP. Visit www.nlom.usu.edu to access the National Library of Virtual Manipulatives, where the APPs were downloaded. The idea instruction made use of the Right Triangle Solver and Pythagorean theory applets. To help pupils practice using virtual manipulatives, the instructor showed them applets. The pupils choose the Pythagorean theory applet from the geometry section under Grades 9–12. The theory and its demonstration are defined and read out to the pupils. They see the theorem in the screen environment, test the proof by changing the sides to make various triangles, and demonstrate the proof with two riddles. Students continue by opening the Right Triangle Solver applet in the same way in week two. They go through practice problems that test their understanding of the theorem and trigonometric functions. When given the other two sides and the angles of a right triangle, they solve for the unknown side. Both groups are given a Post-GII and GAT after two weeks of the course, and their results are recorded for analysis. We used standard deviation and mean as inferential statistics to address our research questions, and we evaluated our hypotheses using analysis of covariance (ANCOVA) at the 0.05 level of significance.

Results

Research Question 1: What is the mean interest rate of JSS3 students taught geometry using virtual manipulatives and those taught using the lecture method?

Table 1: Interest Mean Ratings and Standard Deviation of Junior Secondary School three (JSS3) students of the Experimental and Control Group.

Groups	N	Pre-GII		Post-GII	
		Mean	SD	Mean	SD
Experimental	62	1.78	0.34	2.98	0.41
Control	58	1.69	0.36	2.29	0.39
Mean Difference		0.09		0.69	
Total	120				

Table 1 displays the results of the pre-Geometry Interest Inventory (GII), which reveals that the experimental group had an average interest level of 1.78 (standard deviation=0.34), while the control group had an average interest rating of 1.69 (standard deviation=0.36). A discrepancy of 0.09 is their mean. After the GII, students in the experimental group rated their interest at 2.98 on a scale from 0.41 to 0.39, while those in the control group rated it at 2.29. The mean post-GII interest ratings for the control group were 0.69 points lower than those for the experimental group.

Hypothesis 1: There is no significant difference between the mean interest rating of JSS3 students taught geometry using virtual manipulation and those taught using the lecture method.

Table 2: Analysis of Covariance Result of Junior Secondary School three (JSS3) students of the Experimental and Control Group in Geometry Interest Inventory.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1508.845[a]	2	754.423	49.228	.000	.457
Intercept	2363.668	1	2363.668	154.236	.000	.569
PREGIISCORES	78.035	1	78.035	5.092	.026	.042
GROUP1	**1330.198**	**1**	**1330.198**	**86.799**	**.000**	**.426**
Error	1793.022	117	15.325			
Total	87360.000	120				
Corrected Total	3301.867	119				

R Squared = .457 (Adjusted R Squared = .448)

p = 0.00< 0.05 level of significance is shown by the interest mean ratings of JSS3 pupils taught geometry in the experimental and control groups in table 2. This led to the rejection of the null hypothesis. This indicates that compared to pupils taught geometry using the lecture technique, those taught utilizing virtual manipulatives show a considerable difference in their motivation in studying the subject.

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Research Question 2: What is the achievement mean score of JSS3 students taught geometry using virtual manipulatives and those taught using lecture method?

Table 3: Achievement Mean Scores and Standard Deviation of Junior Secondary School Three (JSS3) students of the Experimental and Control Group.

Groups	N	Pre-GAT		Post-GAT	
		Mean	SD	Mean	SD
Experimental	62	7.65	1.87	16.71	1.66
Control	58	7.59	2.21	11.93	2.37
Mean Difference		0.09		4.78	
Total	120				

At the Pre-GAT, the experimental group averaged 7.65 points with a standard deviation of 1.87, according to Table 3, while the control group averaged 7.59 points with a standard deviation of 2.21. They vary by 0.06 on average. Table 2 further indicated that after the GAT, the control group had an average score of 11.93 and a standard deviation of 2.37, but the experimental group had an average score of 16.71 and a standard deviation of 1.66. There was a 4.78 standard deviation difference between the two groups' average accomplishment scores.

Hypothesis 2: There is no significant difference between the mean score of JSS3 students taught geometry using virtual manipulation and those taught using the lecture method.

Table 4: Analysis of Covariance Result of Junior Secondary School three (JSS3) students of Experimental and Control Group in Geometry Achievement Test.

Source of Variance	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	743.220[a]	2	371.610	101.211	.000	.634
Intercept	1077.260	1	1077.260	293.402	.000	.715
PREGATSCORES	58.919	1	58.919	16.047	.000	.121
GROUP1	**678.317**	**1**	**678.317**	**184.746**	**.000**	**.612**
Error	429.580	117	3.672			
Total	26056.000	120				
Corrected Total	1172.800	119				

R Squared = .634 (Adjusted R Squared = .627)

The results from the experimental and control groups for Junior Secondary School three (JSS3) pupils taught geometry were statistically significant (p= 0.00 < 0.05) according to Table 4. That being the case, we can rule out the possibility of a non-significant difference. This demonstrated that the virtual manipulation mode of instruction significantly outperformed the lecture technique in terms of student accomplishment.

Discussion

This research found that using virtual manipulatives in the classroom increased students' interest in and performance in geometry, which was a focus area for Junior Secondary School three (JSS3). The hoped-for improvement in engagement and performance is a direct outcome of student-centered, interest-based instruction that makes use of technology to inspire active engagement from each and every one of its users. The hypothesis test stated that, when taught geometry using virtual manipulatives, JSS3 pupils show significantly different levels of engagement. This finding accords with the research of Takor et al. (2015), who confirmed that students' interest in studying algebra—a area of mathematics similar to geometry—is enhanced by the use of virtual manipulatives. The results of this research are consistent with those of Moyer-Packenham (2013), who found that, when compared to other forms of education, the use of virtual manipulatives improved students' mathematical understanding. She testified that using virtual manipulatives in the classroom makes math more engaging for students because it draws their attention, inspires them to think creatively, gives them access to multiple solutions to problems, ensures accuracy and efficiency, and lets them connect what they see with what they do in real time.

The research also found that compared to students taught using the lecture approach, JSS3 pupils taught using virtual manipulatives had significantly higher accomplishment. The results of Ukeagbu et al. (2017) corroborate

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these findings, showing that students in primary six do better in mathematics when they utilize virtual manipulatives. The results of this research are in agreement with those of Bolyard and Packenham (2006), who found that using virtual manipulatives improved students' performance in addition and subtraction with integers. Mathematical instruction, according to the study's results, should facilitate students' ability to see complicated connections, be participatory (including hands-on activities), stimulate their interest, and encourage them to solve problems

Conclusion

The findings of this study underscore the effectiveness of virtual manipulatives in enhancing both students' interest and academic performance in geometry among JSS3 pupils. The significant improvement observed in students taught with virtual manipulatives, compared to those exposed to traditional lecture methods, highlights the importance of adopting student-centered, technology-driven instructional strategies in mathematics education. These results, which align with previous studies, affirm that virtual manipulatives not only make learning more interactive and engaging but also promote deeper understanding and improved problem-solving skills. Therefore, integrating virtual manipulatives into mathematics instruction is strongly recommended to foster meaningful learning experiences and better academic outcomes.

Recommendations

The following recommendations were put forward:

1. Mathematics teachers should adopt teaching methods that is interactive to reduce the abstract nature of the subject and arouse students' interest and make improvise in the absence or limited physical learning manipulatives.
2. Mathematics teachers should try and update themselves by attending workshops conferences and training with the latest technological learning tools.
3. Government should equip our schools with the latest technological laboratories.

References

Adebayo, B. (2013). Effects of teaching methods on students interest in mathematics. *Journal of education and human development, 2(1), 1-8.*

Adebule, S. O., & Ayoola, O. O. (2015). Evaluation of instructional materials commonly used in the teaching of mathematics in junior secondary schools in Ekiti state. *Journal of Research on Humanities and Social Science, 18, (5), 144-149.*

Attah, B. G. (2016). An Evaluation of Remedial Mathematics Programme in the University of Jos, Nigeria, Unpublished Thesis.

Bolyard, J. & Packenham, P. M. (2006). Virtual Manipulatives in the K-12 classroom. Proceedings of the annual meeting of the North American chapter of the international group for the psychology of mathematics education. Merida, Mexico: Universal pedagogical.

Borba, M. C. (2011). Virtual manipulatives: A new perspective on mathematics education. *Journal of Mathematical Behaviour, 30(2), 131-142.*

Elisha, H. (2022). How Manipulatives affect the mathematics achievement of students in Nigeria schools. *Educational Research Quaterly, 31(1).*

Ezekiel, D. Y. & Amino (2018). Science, technology, engineering and mathematics (STEM) education for sustainable national economic growth. The 59th annual conference proceedings of science teachers association of Nigeria.

Gadanidis, G. (2011). Exploring the potential of virtual manipulatives for mathematics education. *Journal of Mathematics Teachers Education, 14(2), 131-143*

Gunjan (2016). Using a math game to improve basic math skills. *INTED2018 Proceedings, 1*. https://doi.org/10.21125inted.2018.0634.

Ikeji, C. (2013). The role of resources in mathematics education in Nigeria. *Journal of Education and Human Development, 2(2,) 1-8.*

Leinwarnd, S. E. (2014). National council of teachers of mathematics. Principles ro actions: Ensuring Mathematical success for all. Reston, VA: Author.

Moyer-Packenham, P. S. (2013). Effects of virtual manipulatives on students' achievement and mathematics learning. *International Journal of Virtual and Personal Learning Environments, 4(3), 35-50.*

Musa, M., & Dauda, E. S. (2014). Treads analysis of students' mathematics performance West African senior certificate examination from 2003 to 2013. Implications for Nigerian's vision 20:2020. *British Journal of Education, 2(7).*

Ogbonnaya, U. (2012). The impact of teachers' qualification on students' interest in mathematics. *Journal of Education and Human Development, 1(1), 1-8*

Ogundipe, T. (2015). Math Anxiety and students interest in mathematics. *Journal of Mathematics Education, 8(1), 1-10.*

Okereke, C. (2015). Effects of methods on students interest in mathematics. *Journal of Education and Human development, 4(2), 1-8.*

Reimer, K. (2004). Virtual manipulatives: A review of the literature. *Journal of Educational Multimedia and Hypermedia, 13(3), 241-256.*

Takor, D. I., Iji, C. O., & Abakpa, B. O. (2015). Effect of mathematics manipulatives on upper basic one students' interest in algebra in Kwande local government area, Benue state. *Asian Pacific Journal of Multidisciplinary Research, 3(5), 96-102.*

Ukaegbu, M., Anulobi, J. & Umamba, E. (2017). Effect of virtual manipulatives on pupils' achievement and attitude in mathematics: A case for sustainable Development. Proceedings of the 38th annual international conference of educational media and technology association of Nigeria (EMTAN)