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Enhancing Junior Secondary School Students' Achievement in Geometry Using Geometer's Sketchpad in Nsukka Local Government Area of Enugu State, Nigeria

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ABSTRACT

This study examined the effect of Geometer's Sketchpad (GSP) on achievement in geometrical concepts among JSS students in Nsukka LGA of Enugu State, and whether the effect differs by gender. Two research questions and two null hypotheses guided the study. The study used a quasi-experimental, non-equivalent pre-test, post-test control group design with intact classes. The population was 5,056 JSS3 students in 30 secondary schools in Nsukka LGA in the 2024/2025 session. The sample was 157 students from two co-educational schools with computer laboratories: 78 in the experimental group taught with GSP, and 79 in the control group taught with the conventional method. Data were collected with a 30-item Geometry Achievement Test (GAT) covering angles, triangles, polygons, circles and construction. Each item carried 2 marks, for a total of 60 marks. The instrument was validated by three experts and its reliability established with Kuder-Richardson Formula 20. Mean and standard deviation answered the research questions, while ANCOVA, with pre-test as covariate, tested the hypotheses at 0.05 level. Students taught with GSP achieved significantly higher than those taught with the conventional method ($F = 76.013$, $p < .05$). The experimental group had a post-test mean of 55.61, gain 33.44, while the control group had 37.78, gain 15.95. Gender had no significant influence ($F = 0.022$, $p = .883$). GSP therefore improved achievement equally for male and female students. The study recommended that teachers should embrace GSP, teacher education institutions should train pre-service teachers on its use, and government should provide ICT facilities.

Keywords: Geometer's Sketchpad, Achievement, Geometry, Gender, ICT

INTRODUCTION

Mathematics forms the base on which science, technology, engineering and commerce stand. A country that neglects mathematics cannot build industries, cannot grow its technology and cannot compete in a modern economy. Inside mathematics, geometry holds a central place. Geometry deals with shapes, sizes, positions and measurement of figures in space. In the Nigerian Basic Education Curriculum, geometry takes up a large share of the mathematics content, from identification of plane shapes in JSS1 to angles, triangles, polygons, circles and construction in JSS3 (Federal Ministry of Education, 2025; NERDC, 2025). In spite of this large allocation, achievement in geometry in Junior Secondary Schools in Enugu State, particularly Nsukka LGA, has remained persistently low and worrisome.

The Chief Examiners' Reports on Basic Education Certificate Examination (BECE) Mathematics have repeatedly identified geometry as an area of weakness. Many candidates could not apply the exterior angle theorem, could not calculate angles in plane figures, and left geometry questions unattempted (BECE Report, 2020-2023).The weakness of students in geometry has several causes. Geometry is abstract and demands spatial reasoning, which many learners have not yet developed. Instructional materials are scarce. Classes are large. Many students suffer mathematics anxiety. Above all, the method of teaching is a major factor. Akobundu et al. (2025) and Odo et al. (2024) observed that geometry requires spatial reasoning and that many Nigerian students struggle to develop it under the conventional lecture method. That method, often described as talk-chalk and teacher-dominated, leaves learners as passive listeners who copy notes and memorise formulae (Adelabi, 2020). Recent studies in Nigeria show the same pattern: when the method is passive, achievement drops, even when students are intelligent (Sabitu & Khalid, 2024; Uzuegbu et al., 2025; Oloda et al., 2025). Gender is another factor examined in this study.

In this study, gender means the socially constructed expectations attached to being male or female in the Nsukka cultural setting, not biological sex alone. In many Nigerian communities, there is a widespread belief that mathematics, especially geometry which requires spatial visualisation, belongs to boys. Odo et al. (2024) in Nsukka found that boys still outperformed girls in geometry when taught with conventional method. However, Uzuegbu et al. (2025), Sabitu and Khalid (2024) and Oloda et al. (2025) found no significant difference between boys and girls when the method was interactive. This suggests that the gender gap may be caused by the method, not by ability, and that it can be closed with an interactive method.

The 21st century has shifted teaching from teacher-centred to learner-centred, technology-driven pedagogy. The Federal Republic of Nigeria National Policy on Education (2014) and the National Policy on ICT in Education (Federal Ministry of Education, 2019) both emphasise the integration of Information and Communication Technology (ICT) into teaching and learning. One ICT tool specifically designed for teaching geometry is Geometer's Sketchpad (GSP).

GSP was developed by Jackiw (1991) as a dynamic geometry environment. Unlike a static chalkboard drawing, a figure constructed in GSP remains linked to its geometric rules. When a learner drags a vertex, the measurements update but the properties are preserved. This allows learners to test their own ideas, to see many examples at once, and to discover properties by themselves, instead of waiting for the teacher to tell them. Recent evidence confirms that this kind of interactive visualisation strengthens geometric imagination, spatial reasoning, problem-solving and deep understanding of geometric concepts (Adelabi, 2020; Akobundu et al., 2025). In Nigeria, Akinoso (2014) in Ogun State, Okoro and Ike (2021) in Anambra, and Emaikwu et al. (2022) in Benue reported similar positive effects of GSP. However, most of those studies focused on Senior Secondary School students, not Junior Secondary. Few of them examined gender as a moderating factor in Enugu State, particularly in rural areas like Nsukka LGA, where ICT facilities are limited and gender stereotypes are stronger. There is therefore a need to investigate whether GSP can improve achievement in geometry among JSS3 students in Nsukka, and whether it works equally for boys and girls.

Despite the importance of geometry in mathematics curriculum and its application in daily life, students' achievement in geometry in junior secondary schools in Nsukka Education Zone, Enugu State has remained persistently poor. This poor achievement is largely attributed to the conventional lecture method used by mathematics teachers. This method does not develop spatial visualization and does not allow students to explore and discover geometric properties themselves. Geometer's Sketchpad (GSP), a dynamic geometry software, has been found to improve achievement in developed countries by making geometry visual, interactive and discovery-based. However, its effect has not been adequately tested in Nsukka Education Zone where schools lack ICT facilities and gender stereotypes are strong. There is therefore need to empirically determine whether GSP can improve students' achievement in geometry and whether its effect differs for male and female students. This is the problem this study seeks to address. The general purpose is to determine the effect of Geometer's Sketchpad on students' achievement in geometrical concepts with gender as moderating factor.

Specifically, the study seeks to:

1. Determine the effect of Geometer's Sketchpad on students' achievement in geometrical concepts in junior secondary schools in Nsukka Education Zone.
2. Determine the influence of gender on students' achievement in geometrical concepts when taught with Geometer's Sketchpad.

Research Questions

1. What is the effect of Geometer's Sketchpad on students' mean achievement scores in geometrical concepts?
2. What is the difference in mean achievement scores of male and female students taught geometrical concepts with Geometer's Sketchpad?

Hypotheses

1. There is no significant difference in mean achievement scores of students taught geometry with Geometer's Sketchpad and those taught with conventional method.
2. There is no significant difference in mean achievement scores of male and female students taught geometry with Geometer's Sketchpad.

METHODS

The study adopted a quasi-experimental research design, specifically the non-equivalent pre-test, post-test control group design. This design was considered appropriate because intact classes were used without randomization of subjects into groups, which is common in school-based research. The study was carried out in Nsukka Local Government Area of Enugu State, Nigeria. Nsukka LGA is one of the local government areas that make up Nsukka Education Zone. The area was chosen because of observed persistent poor performance of students in geometry in Basic Education Certificate Examination and presence of schools with ICT facilities.

The population comprised all Junior Secondary School Three (JSS3) students in public secondary schools in Nsukka LGA in 2024/2025 academic session. There were 30 secondary schools with a total of 5,056 JSS3 students (2148 males and 2912 female); (Enugu State Post Primary Schools Management Board, 2025). The sample of this study consists of 157 students (95 females and 62 males). Multi-stage sampling procedure was employed. First, purposive sampling was used to select two co-educational schools that have functional computer laboratories and mathematics teachers who are computer literate. Second, simple random sampling by balloting was used to assign one school to experimental group (78 students) and the other to control group (79 students). Two intact classes from each school were used to avoid disruption of normal school activities.

The instrument used is Geometry Achievement Test (GAT): A 30-item multiple-choice objective test, with four response options constructed by the researcher based on JSS3 curriculum covering angles, triangles, polygons, circles and construction. Each correct answer attracts 2 marks, total 60 marks. The instrument was developed using test blue print (Table of specification). The GAT and lesson plans were subjected to face and content validation by three experts; two from Mathematics Education and one from Measurement and Evaluation, all from Department of Science Education, University of Nigeria, Nsukka. They suggested that items testing each level of cognitive development should match the level of objectives in the curriculum. Their suggestions were incorporated to improve the quality of instruments. The GAT was trial tested using 30 JSS three students from a co-education school outside the area of the study. The data obtained were used to determine the internal consistency of the item. This was done through the use of Kuder Richard Formular 20 (K-R 20) because the score obtained were dichotomously scored. The obtained internal consistency reliability estimate is 0.91 indicating high internal consistency.

The researcher obtained permission from principals of selected schools. Mathematics teachers in selected schools were trained for one week on how to use Geometer's Sketchpad lesson plans and conventional lesson plans.

- Week 1: Pre-test administration. GAT was administered to both groups as pre-test.
- Weeks 2-7: Teaching. The experimental group was taught geometry concepts using lesson plans developed with Geometer's Sketchpad. Students interactively constructed figures, dragged, measured and discovered properties. The control group was taught same concepts using conventional lesson plans: chalk, ruler, protractor and blackboard.
- Week 8: Post-test administration. GAT was reshuffled and administered as post-test to both groups. Scripts were collected and scored.

Mean and standard deviation were used to answer research questions. Analysis of Covariance (ANCOVA) was used to test null hypotheses at 0.05 level of significance, using pre-test as covariate to control for initial differences between groups.

RESULTS

Research Question One: What is the effect of Geometer's Sketchpad on students' mean achievement scores in geometrical concepts?

Table 1: Mean and Standard Deviation of Achievement Scores of Students Taught Geometry Using Geometer Sketchpad and Those Taught Geometry without Geometer's Sketchpad

Group	Pre-test			Post-test		
	N	Mean	SD	Mean	SD	Mean Gain
Experimental	78	22.17	9.92	55.61	12.32	33.44
Control	79	21.83	12.25	37.78	12.62	15.95

Table 1 shows that both groups had similar pre-test means (22.17 vs 21.83); indicating homogeneity at entry. After treatment, experimental group had post-test mean of 55.61 with gain of 33.44 while control group had 37.78 with gain of 15.95. This indicates that students taught with Geometer's Sketchpad achieved higher than those taught without Geometer's Sketchpad.

Research Question Two: What is the difference in mean achievement scores of male and female students taught geometrical concepts with Geometer's Sketchpad?

Table 2: Mean and Standard Deviation of Achievement Scores of Male and Female Students in Geometry

Gender	**Pre-Test**			**Post-Test**		
	N	Mean	SD	Mean	SD	Mean Gain
Female	64	20.85	11.25	45.64	14.72	24.79
Male	93	22.79	11.02	48.05	15.80	25.26

Table 2 shows that male students had slightly higher post-test mean (48.05) than female (45.64). The mean gain scores of 25.26 and 24.79 for male and female students respectively have indicated that male students achieved higher than their female counterparts.

Hypothesis One: There is no significant difference between the mean achievement scores of students taught geometry using Geometer's Sketchpad and those taught geometry without Geometer's Sketchpad.

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Table 3: Analysis of Covariance of the Effect of Geometer Sketchpad on Students' Achievement in Geometry

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	12506.980[a]	4	3126.745	19.710	.000
Intercept	71557.174	1	71557.174	451.071	.000
Pretest	23.464	1	23.464	.148	.701
Group	12058.612	1	12058.612	76.013	.000
Gender	3.433	1	3.433	.022	.883
Group * Gender	.028	1	.028	.000	.989
Error	24113.046	152	158.638		
Total	378189.000	157			
Corrected Total	36620.025	156			

a. R Squared = .342 (Adjusted R Squared = .324)

The analysis of data in Table 3 shows that the probability associated with the calculated value of F (76.013) for the effect of Geometer's Sketchpad on students' achievement in geometry is 0.000. Since the probability value of .000 is less than the .05 level of significance ($p < .05$), the null hypothesis was rejected. Thus, there is a significant difference in the mean achievement scores of students taught geometry using Geometer's Sketchpad and those taught geometry without Geometer's Sketchpad in favour of the experimental group.

Hypothesis 2: There is no significant difference between the mean achievement scores of male and female students in geometry.

Table 3 shows that the probability associated with the calculated value of F (0.022) for the influence of gender on students' achievement in geometry is 0.883. Since the probability value of 0.883 is greater than the 0.05 level of significance ($p > .05$), the null hypothesis was NOT rejected. Thus, gender has no significant influence on the achievement of students in geometry. The interaction effect of group and gender was also not significant ($F = 0.000$, $p = 0.989$).

DISCUSSION

The result of this study showed that GSP has a significant effect on students' achievement in geometry. The experimental group, taught with GSP, performed significantly better than the control group, taught with conventional method. The pre-test means of the two groups were almost the same (22.17 vs 21.83), which shows that they started at the same level. After treatment, the experimental group rose to 55.61 with a gain of 33.44, while the control group rose to only 37.78 with a gain of 15.95. The ANCOVA result confirmed that the difference was significant ($F = 76.013$, $p < .05$).This finding is consistent with earlier studies. Akinoso (2014), Okoro and Ike (2021) and Emaikwu et al. (2022) all reported that GSP improved achievement in geometry in different parts of Nigeria. It is also consistent with recent Nigerian studies on interactive methods: Sabitu and Khalid (2024) found that Computer Animation improved achievement in geometry in Oyo, Uzuegbu et al. (2025) found that Cubing and Jigsaw strategies improved achievement in geometry in Rivers State, and Oloda et al. (2025) found that Audio-Visual instruction improved achievement in geometry in Ondo State. The reason for this improvement is not magic, It is the method. In the conventional method, the teacher draws a parallelogram on the board and tells students that opposite sides are equal. Students copy and memorise. In GSP, the student constructs the parallelogram, drags a vertex, measures the sides, and sees by himself that opposite sides remain equal no matter how the shape changes. That is learning by discovery. It builds spatial reasoning, it sustains attention, and it makes the concept stick. The dragging feature also allows the student to see many examples in minutes, without drawing each one with paper and pencil.

The result also showed that gender had no significant influence on achievement in geometry when students were taught with GSP. Male students had a slightly higher post-test mean (48.05) than female students (45.64), but the difference was not significant ($F = 0.022$, $p = .883$). The interaction of group and gender was also not significant ($F = 0.000$, $p = .989$). This means GSP worked equally for boys and girls. This finding agrees with Sabitu and Khalid (2024), Uzuegbu et al. (2025) and Oloda et al. (2025), who all reported that gender had no significant effect on achievement in geometry when the method was interactive. It differs from Odo et al. (2024), who found boys outperformed girls in Nsukka under conventional teaching. The difference is explained by the method. Under conventional teaching, boys dominate the classroom, girls are shy to ask questions, and the stereotype that "mathematics is for boys" becomes a self-fulfilling prophecy. Under GSP, every student has a computer, every student constructs, every student drags, every student discovers. No one is left as a spectator. The opportunity to learn is equal, so the outcome is equal. The implication is clear: the gender gap in geometry in Nsukka

is not caused by ability. It is caused by pedagogy. When the pedagogy changes, the gap closes.

CONCLUSION

This study investigated the effect of geometer's sketchpad on students' achievement in geometry. The study also examined the influence of geometer's sketchpad on achievement of male and female students in geometry. The study has shown that the use of Geometer's Sketchpad has a facilitative effect on students' achievement in geometry. There is a significant difference in geometry mean achievement scores of students exposed to the use of Geometer's Sketchpad and those who were not exposed to the use of Geometer's Sketchpad. The study also indicated that there is no significant influence of gender on students' achievement in geometry; thus gender is not a factor in geometry achievement when exposed to the use of Geometer's Sketchpad.

Recommendations

Based on the result of this study, the following recommendations are suggested;

1. Mathematics teachers should embrace the innovative instructional materials such as the use of geometer's sketchpad and other computer software. This will help to correct the impressions the students have about geometry and mathematics in general.
2. To ensure that teachers of mathematics grasp the tenets of the use of geometer's sketchpad, pre-service mathematics teachers should be trained on the use of geometer's sketchpad during their training process by the teacher educators.
3. Ministry of Education policy makers should organize seminars, workshops and conferences on the use of geometer's sketchpad for serving teachers, teacher educators, textbook writers and curriculum developers.
4. Government should provide ICT facilities notably computers in schools so as to provide access to ICT to both teachers and learners to ensure proper implementation of the use of geometer's sketchpad.

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