



Effect of Geogebra and Geometrical Set on Mathematics Students' Academic Interest in Owerri Education Zone

Akobundu, Chinonyerem Amarachi, Ugwu, A.N & Eluwa, I.O
Department of Science Education, Michael Okpara University of Agriculture, Umudike
Corresponding Author: nwosuchinonyerem5@gmail.com

Abstract

This study examined the effect of GeoGebra application and geometrical sets on students' interest in geometry. Two research questions and two null hypotheses guided the study. A pretest posttest non-equivalent groups quasi-experimental design was used. The population was 10,123 Junior Secondary two (JS II) students. A purposive sample of 107 students was selected. Intact classes of JSII students from three schools were used. One group was taught with GeoGebra, another with geometrical sets, and the last group was taught without special tools. A well-validated Mathematics Interest Scale (MIS) with a Cronbach Alpha reliability coefficient of 0.82, was used for data collection. Mean and standard deviation were used to answer the research questions. Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. The results showed that students taught with GeoGebra had higher interest scores than those taught with geometrical sets and those taught without any special tool. Students taught with geometrical sets also showed some increase in interest, but it was less than those taught with GeoGebra. Gender had a significant effect on interest. However, there was no significant interaction effect of gender and instructional tools on students' interest. The study concluded that GeoGebra is more effective than geometrical sets in arousing students' interest in geometry. It recommended that mathematics teachers should adopt GeoGebra in their classrooms. Policymakers should also provide ICT facilities and training for teachers to improve the teaching of geometry.

Keywords: GeoGebra, Geometrical sets, Geometry, Interest, Junior secondary school

Introduction

Continued lack of interest in geometry amongst Nigerian secondary school students has become a burning issue of great concern. This has been consistently highlighted in the West African Examinations Council (WAEC) Chief Examiners' Reports. In 2021, candidates showed reluctance to attempt questions on construction and circle geometry; by 2022, it was lack of enthusiasm to answer questions on bearing and circle geometry; and in 2023, there was declining interest in plane and circle geometry was evident (WAEC, 2021; 2022; 2023). This ugly trend underscores that geometry which is a foundational branch of mathematics, continues to challenge not only students' mastery but also their willingness to engage with the subject. If left unaddressed, this problem will continue to threaten not only students' overall attitudes toward mathematics but also their preparedness for

higher-level studies and the real-world applications of spatial reasoning (Uzuegbu *et al*, 2024). There is therefore an urgent need to explore more effective teaching approaches that can demystify geometry and boost students' academic interest.

Geometry, by its very nature, is highly abstract and requires excellent spatial reasoning skills that many secondary school students in Nigeria struggle to develop. Concepts such as points, lines, planes, angles, and transformations are not always tangible. When these are taught solely through traditional lecture methods, they often remain disconnected from students' lived experiences. In a study conducted by Okigbo and Okeke (2020), the lecture method is more of rote memorization rather than conceptual understanding. This makes it difficult for learners to visualize geometric relationships and sustain curiosity.



More so, it places females at a disadvantage considering the fact that they have less spatial reasoning skills than their male counterpart (Uzuegbu *et al*, 2024). Yet, geometry is not just an important aspect of mathematics, it is central to science, technology, engineering, and architecture. When students show lack of interest in this area, they become disconnected from the subject and achieve little in examinations. Ultimately, they are ill-prepared for future academic and career pursuits. Thus, it is crucial to address the challenges of teaching and learning geometry. It is not only about improving scores but also about cultivating learners' interest towards geometry.

Teaching geometry in schools has remained a challenge for many years as students end up cramming formulas without seeing the relationships between shapes and figures due to the rote memorization inherent in traditional methods. For this reason, many learners lose interest in geometry and find it difficult to sustain curiosity. They perform poorly in examinations, disconnected from the subject, and face difficulties in future studies or careers. Improving the teaching and learning of geometry is not only about raising test scores. It is also about building motivation and positive attitudes that can support national development.

Instructional tools can play an important role in addressing this challenge. For instance, geometrical sets (rulers, compasses, protractors, and set squares) are simple tools that get students to involved in geometry lessons. Instead of becoming passive listeners during classes, they construct figures, measure lines, and see their work take shape. A study by Onwumere and Ugwuegbulam (2020) and Eze and Nworgu (2021) confirmed that learners who use such tools often develop stronger spatial reasoning and show greater interest than those taught through lecture alone. Despite this evidence, many teachers overlook their value. The lecture method is usually preferred because it feels quicker and easier to manage. However, this is a costly approach as students miss out on the hands-on experiences that bring geometry to life (Okeke & Aja, 2022). This situation does not spell good for the students. This is because geometrical sets are not expensive, they are effective, and they are already available in most schools. Making better use of them could do much to spark curiosity and sustain their interest.

Furthermore, technology has also introduced new possibilities in learning. One of the most popular innovations is a software (GeoGebra) which provides a platform for teachers and students to create interactive

diagrams. With GeoGebra, students can visualize geometry concepts in real time and test mathematical ideas. Studies have shown that this software can help students have a more comprehensive conceptual understanding of abstract concepts which makes them think critically, and even sustain curiosity and interest in geometry (Achor & Umoru, 2019; Usman & Akinyemi, 2021). Despite these benefits, GeoGebra is not widely used in Nigerian schools. The reasons include lack of teacher training, inadequate resources (personal computers/laptops, data cost, etc.), and poor awareness of its value (Akani & Eke, 2023). This is why the lecture method continues to dominate. However, this has been criticized for making students passive and uninterested in mathematics (Iji & Abah, 2020). The ultimate outcome is an imbalance which creates too much reliance on lecture, too little use of geometrical sets, and very limited adoption of GeoGebra.

This situation calls for a closer look. Each method (GeoGebra, geometrical sets, and lecture) has strengths. Yet there is not enough comparative evidence to show which is most effective for sustaining students' interest in geometry (Odey & Onah, 2020; Achor & Okoh, 2022). Many previous studies focus on one method at a time. This have left teachers to make choices based on habit rather than research. Questions about gender differences also remain unresolved. Some studies say that male students show greater interest because of their stronger spatial reasoning skills (Nwoye & Abah, 2021) while some others report that there are no significant gender differences when effective instructional tools like GeoGebra nd geometrical set are used (Eze & Okeke, 2023). These mixed findings suggest that both teaching method and gender may influence students' interest.

For the above reasons, this study sought to compare the effects of GeoGebra, geometrical sets, and lecture on students' interest in geometry, while also exploring gender differences. The outcome of this study will provide evidence that can help teachers, policymakers, and curriculum planners. The main objective is to identify strategies that can increase students' interest and make geometry a subject that truly inspires learning in junior secondary schools in Imo State.

Literature Review

This study is grounded on the Constructivist Theory of Learning. This theory emphasizes that learners develop interest and understanding when they actively interact with learning materials and construct knowledge for themselves. Constructivism suggests that students'

enthusiasm and curiosity can be aroused when they manipulate tools such as rulers, compasses, and protractors, or when they engage with a dynamic software like GeoGebra that allows them to visualize and experiment with abstract ideas.

There are related empirical studies for this study. In Nigeria, Bassey and Ogbonna (2023) examined the effect of GeoGebra on junior secondary students' learning experiences in Akwa Ibom State. The study adopted a quasi-experimental design and they found that students taught with GeoGebra not only achieved better results but also demonstrated higher levels of interest compared to peers taught using lecture method. Their study shows the potential of digital tools in sustaining engagement in mathematics classrooms. Similarly, in Ghana, Wonu, Kakraba, and Auwal (2024) investigated the role of GeoGebra-assisted instruction in fostering undergraduate students' interest in geometry. Their findings revealed that learners exposed to GeoGebra had greater enthusiasm and willingness to participate in lessons, with no significant difference in interest between male and female students. This suggests that interactive software can bridge gender disparities in engagement. On the other hand, Ndioho and Olajide (2020), working with senior secondary students in Degema, assessed the effect of geoboard manipulatives on students' interest in geometry. Their results showed no significant difference in interest between the experimental and control groups, though some students still benefited from the hands-on experience.

Collectively, these studies demonstrate that while both traditional instruments and dynamic software can support geometry learning, GeoGebra appears more effective in sustaining students' academic interest. However, few studies have directly compared GeoGebra with geometrical sets, leaving a gap that this study intends to address.

Research Questions

1. What are the mean interest scores of students taught geometry using GeoGebra, geometrical sets, and those taught without these facilities?
2. What is the interaction effect of gender and instructional materials on students' mean interest scores in geometry?

Hypotheses (H_0)

1. H_{01} : There is no significant difference in the mean interest scores of students taught

geometry using GeoGebra, geometrical sets, and those taught without these facilities.

2. H_{02} : There is no significant interaction effect of gender and instructional materials on students' mean interest scores in geometry.

Methodology

The study adopted a quasi-experimental design, specifically the pretest-posttest non-equivalent control group design. This design was suitable since intact classes were used without random assignment to avoid disrupting the normal school setting. The population of the study consisted of 10,123 Junior Secondary Two (JS2) students in the Owerri Education Zone of Imo State. From this population, a sample of 107 students was drawn using purposive sampling techniques.

The sample consisted of students from three schools: 35 were assigned to the GeoGebra Application group, 37 to the Geometrical Sets group, and 35 to the Control group, which was taught using the conventional lecture method. The instrument for data collection was the Mathematics Interest Scale (MIS), a 20-item tool designed to measure students' interest in learning mathematics using a modified four-point Likert scale. The instrument was validated by experts in mathematics education and measurement and evaluation, and its reliability was established using Cronbach's alpha, yielding a coefficient of 0.82.

The treatment lasted for four weeks, during which trained mathematics teachers implemented the instructional strategies following standardized lesson plans. Data were collected from pretest and posttest administrations of the Mathematics Interest Scale (MIS) and analyzed using mean and standard deviation to answer the research questions, while Analysis of Covariance (ANCOVA) was employed to test the null hypotheses at the 0.05 level of significance. To ensure the validity of the study, key extraneous variables were carefully controlled. The teacher variable was addressed by training the teachers and providing detailed lesson plans to ensure uniform instructional delivery, while the Hawthorne effect was minimized by using students' regular mathematics teachers for the lessons. Intergroup and initial group differences were controlled statistically through ANCOVA, ensuring that observed differences in interest were attributable to the instructional interventions rather than pre-existing variations or other extraneous factors.

Results

Research Question 1

Table 1: Mean interest scores and standard deviations of students taught geometry using GeoGebra application, geometrical sets and those taught without them.

Materials	N	Pre-test \bar{X}	SD	Post-test \bar{X}	SD	Mean Interest Gain
GeoGebra Application	35	34.17	4.82	61.23	5.94	27.06
Geometrical sets	37	33.03	4.55	58.43	9.81	25.40
Control	35	34.27	4.39	48.70	10.06	13.43

The results in Table 1 show that all groups had similar pre-test mean scores, with GeoGebra ($\bar{X} = 34.17$, $SD = 4.82$), geometrical sets ($\bar{X} = 33.03$, $SD = 4.55$), and the control group ($\bar{X} = 34.27$, $SD = 4.39$), indicating comparable baseline levels of interest in geometry across the three groups. Following the treatment, the post-test mean scores revealed a notable increase in interest for the experimental groups. Students taught using the GeoGebra application achieved the highest post-test mean ($\bar{X} = 61.23$, $SD = 5.94$) with a mean interest gain of 27.06, while those taught with

geometrical sets recorded a post-test mean of 58.43 ($SD = 9.81$) and a gain of 25.40. In contrast, the control group, which received traditional instruction without these instructional materials, had a post-test mean of 48.70 ($SD = 10.06$) and a gain of 13.43. These results suggest that the use of GeoGebra and geometrical sets significantly enhanced students' interest in geometry, with GeoGebra being slightly more effective in stimulating interest compared to geometrical sets, while conventional teaching methods produced comparatively lower interest gains.

Hypothesis 1:

Table 2A: Summary of Analysis of Covariance (ANCOVA) of Students' post-interest scores Classified by instructional materials with Pre-interest Scores as Covariate

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	4734.469 ^a	6	789.078	12.115	.000
Intercept	2799.699	1	2799.699	42.983	.000
Pre-interest	385.195	1	385.195	5.914	.017
Materials	3166.558	2	1583.279	24.308	.000
Gender	19.760	1	19.760	.303	.583
Gender*Materials	1070.520	2	535.260	8.218	.000
Error	6513.493	100	65.135		
Total	343576.000	107			
Corrected Total	11247.963	106			

a. R Squared = .421 (Adjusted R Squared = .386)

Table 2 has shown that F-ratio (8.218) is significant at .000 for instructional materials, at 2 and 106 degrees of freedom (df). This is because, .000 is less than .05 significant level earlier set for the hypothesis. Hence the hypothesis is rejected. Therefore, there is a significant difference in the mean interest scores of students taught

geometry using GeoGebra application, geometrical sets and those taught without them.

In order to ascertain the direction of the significance, the scores were subjected to post hoc analysis as shown in Table 3.

Table 3: LSD Post hoc Analysis of Students' Post-interest scores Classified by Instructional Materials

(I) Method	(J) Method	Mean Difference (I – J)	Standard Error	Sig. (p)
GeoGebra Application	Geometrical Set	2.800	2.083	.188
	Control	12.5268*	2.112	.000
Geometrical Set	GeoGebra	-2.800	2.083	.188
	Control	9.726*	2.083	.000
Control	GeoGebra	-12.5268*	2.112	.000
	Geometrical Set	-9.726*	2.083	.000

* = Significant at .05 level of significance

The results in Table 3 show that there were significant differences in students' post-interest scores in geometry across the three instructional groups. Specifically, students taught with GeoGebra recorded significantly higher mean interest scores than those in the control group, with a mean difference of 12.53, which was statistically significant at $p < .05$. Similarly, students taught with the Geometrical Set performed significantly better than those in the control group, with a mean difference of 9.73, also significant at $p < .05$. However,

when comparing GeoGebra and Geometrical Set directly, the mean difference of 2.80 was not statistically significant, indicating that the two methods were equally effective in enhancing students' interest. These findings suggest that while both GeoGebra and Geometrical Set are effective instructional tools for stimulating students' interest in geometry, GeoGebra produced a slightly greater but non-significant advantage.

Research Question 2

Table 4: Mean interest and Standard deviation scores of male and female students taught geometry using GeoGebra Application, Geometrical Set and those taught without.

Instructional Materials	Gender	N	Pretest (\bar{X})	SD	Posttest (\bar{X})	SD	Mean Gain
Geometrical Set	Male	17	32.76	4.51	45.42	9.34	12.66
	Female	20	35.55	3.29	51.50	10.01	15.95
GeoGebra Application	Male	16	32.42	3.31	61.53	5.97	29.11
	Female	19	36.25	4.89	60.88	6.09	23.63
Control Group	Male	15	33.20	3.46	47.15	4.69	13.95
	Female	20	35.34	4.28	50.25	5.53	14.91

The results show that both male and female students had gains in interest in all groups. For the Geometrical Set, female students had higher posttest scores ($\bar{X} = 51.50$, $SD = 10.01$) and a larger gain (15.95) than male students ($\bar{X} = 45.42$, $SD = 9.34$; gain = 12.66). In the GeoGebra group, male students had slightly higher posttest scores ($\bar{X} = 61.53$, $SD = 5.97$) and gain (29.11) than female students ($\bar{X} = 60.88$, $SD = 6.09$; gain = 23.63). In the control group, female students again had higher posttest scores ($\bar{X} = 50.25$, $SD = 5.53$; gain =

14.91) than male students ($\bar{X} = 47.15$, $SD = 4.69$; gain = 13.95). These results suggest that the type of instructional material affects students' interest differently for males and females. GeoGebra was most effective for increasing male students' interest, while the Geometrical Set showed a slightly greater effect for female students. Ultimately, there is an interaction effect between gender and instructional materials on students' interest in geometry.

Hypothesis 2:

Table 5: Analysis of covariance on interaction effect of gender and instructional materials (GeoGebra and Geometrical Set) on students' mean interest scores in geometry.

Source	SS (Sum of Squares)	df	MS (Mean Square)	F	Sig. (p)	Decision
Corrected Model	1,100.468	4	275.117	7.366 ^a	.000	S
Intercept	20,057.475	1	20,057.475	537.002	.000	S
PRETEST	368.526	1	368.526	9.867	.002	S
GENDER	693.928	1	693.928	18.579	.000	S
MATERIALS	13.270	1	13.270	0.355	.553	NS
GENDER × MATERIALS	24.744	1	24.744	0.662	.419	NS
Error	2,502.517	67	37.351			
Total	436,402.000	71				
Corrected Total	3,602.985	71				

a. R Squared = .305 (Adjusted R Squared = .263)

The results of the ANCOVA presented in Table 1.4 show that while pretest scores ($F = 9.867$, $p = .002$) and gender ($F = 18.579$, $p < .001$) had significant effects on students' interest in geometry, the main effect of instructional materials ($F = 0.355$, $p = .553$) and the interaction between gender and instructional materials ($F = 0.662$, $p = .419$) were not statistically significant. This finding suggests that although male and female students differed in their overall mean interest levels, the relative effectiveness of GeoGebra and Geometrical Sets did not depend on gender. Therefore, Hypothesis 2, which states that there is no significant interaction effect of gender and instructional materials on students' interest, is not rejected.

Discussions

The results indicate that students taught geometry using GeoGebra and Geometrical Sets demonstrated higher interest compared to those taught through conventional methods. Both experimental groups had substantial gains in interest, whereas the control group, which received traditional lecture-based instruction, showed relatively lower increases. The lower interest in the control group may be due to the passive nature of conventional teaching, which often limits opportunities for hands-on exploration, visualization, and active engagement. In contrast, GeoGebra allows students to dynamically manipulate shapes and explore geometric relationships, while Geometrical Sets provide tactile experiences that make abstract concepts concrete. These interactive features likely stimulated curiosity, participation, and motivation, contributing to higher interest levels in the experimental groups.

This outcome aligns with the Constructivist Theory of Learning, which emphasizes that learners develop understanding and interest through active engagement with materials. Empirical studies support these findings. Bassey and Ogbonna (2023) reported that students taught with GeoGebra displayed higher motivation and interest compared to peers taught conventionally. Similarly, Wonu, Kakraba, and Auwal (2024) observed that GeoGebra-assisted instruction increased enthusiasm and willingness to participate in lessons. Ndioho and Olajide (2020) also found that geoboard manipulatives enhanced engagement, although with slightly less impact than digital tools. Collectively, these studies demonstrate that interactive instructional materials effectively sustain students' academic interest in geometry.

The results further reveal that both male and female students experienced gains in interest across all instructional methods, though patterns varied slightly. Male students taught with GeoGebra had slightly higher gains, while female students using Geometrical Sets showed marginally greater gains. However, the interaction between gender and instructional materials was not statistically significant, indicating that the relative effectiveness of the tools in enhancing interest did not depend on gender. These outcomes may be explained by the engaging and student-centered nature of both GeoGebra and Geometrical Sets, which provide opportunities for exploration, visualization, and hands-on learning equally appealing to all students.

This finding is consistent with the Constructivist Theory, emphasizing that active engagement drives interest regardless of gender. Supporting evidence comes from Wonu, Kakraba, and Auwal (2024), who

found no significant difference in interest between male and female students exposed to GeoGebra. Similarly, Ndioho and Olajide (2020) observed that geoboard manipulatives enhanced engagement without favoring one gender. These results suggest that interactive tools can effectively foster academic interest in geometry among both male and female students.

Conclusion

This study concludes that integrating dynamic software such as GeoGebra into the teaching of geometry provides a powerful means of enhancing students' academic interest. Geometrical sets also hold value, particularly where digital resources are limited. However, they are less impactful compared to digital tools. Teachers are therefore encouraged to adopt learner-centered, interactive instructional materials to sustain students' interest in geometry.

Recommendations

Based on the findings, the study recommended the following:

1. Mathematics teachers should use dynamic instructional tools such as GeoGebra in classroom practice. Its interactive features allow learners to visualize abstract concepts, which significantly improves their interest in the subject.
2. While GeoGebra proved most effective, geometrical sets still played a role in stimulating students' interest. Teachers in resource-limited schools should continue to employ geometrical sets where technology is unavailable. This will ensure that all learners have access to hands-on learning experiences.

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