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GeoGebra Software and Students' Attitudes Towards Coordinate Geometry in Warri South, Delta State

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Abstract
The study examined the impact of GeoGebra software on the attitudes of students towards the subject of Coordinate Geometry in senior secondary schools 3 (SS 3) in Warri South (Delta State). A quasi-experimental design was used in the pretest-posttest control group design. A sample size of 118 SS 3 Mathematics students in 3 schools was selected. The samples were segmented into two groups: experimental and control groups, taught by means of GeoGebra-assisted instruction and traditional lecture method, respectively. The data collection tool was the Coordinate Geometry Attitude Inventory (CGAI), a 20-item questionnaire. Cronbach's Alpha was used to determine reliability coefficients of 0.86 for the CGAI. The mean and standard deviation provided responses to two research questions, and Analysis of Co-variance (ANCOVA) was employed to test the two hypotheses formulated in the study at a 0.05 level of significance. The result revealed a value of $F_{1,77} = 43.965$, p= .000 ($p < 0.05$), indicating a significant difference between the mean attitude of students taught Mathematics using GeoGebra and those taught using traditional methods. It also discloses a value of $F_{1,42} = 0.442$, p = .510 ($p > 0.05$) showing no significant difference in the attitude of male and female students taught with GeoGebra. The results of this experiment show that the GeoGebra-based method of learning improves the attitude of students towards Coordinate Geometry. The male students have an improved attitude, just a bit more than female students, but the differences were not significant.

Keywords: GeoGebra, Attitude, Coordinate Geometry, Technological, Students

Introduction

In the twenty-first century, the utilisation of new teaching technologies and computer-assisted training is becoming more widely recognised. Mathematics is important in many aspects of real life because it provides the foundation for logical thinking, problem solving, and decision-making across a wide range of areas. According to Bassey (2020), mathematics is the foundation of both national and international development, and it is required to understand and use science and technology. Mathematics is important for both literate and illiterate portions of society because of its applications in everyday life, such as transportation and all forms of trade, as well as its contributions to scientific and technological advancement. Due to its applications in everyday life, such as transportation, all forms of commerce, and contributions to scientific and technical growth, Mathematics is significant for both literate and illiterate segments of society (Golji & Dangpe, 2016). Technology has a crucial role in the growth of a country; in the modern world, technological advancement supports both social and economic advancement. In today's world, science and technology have taken over as the primary instruments for power development. Due to their scientific and technological achievements, nations like China, Japan, America, and Russia are examples of developed nations. GeoGebra is a technical instrument that incorporates every aspect of Mathematics. Many interactive geometry teaching tools are included in the program (Dahal, Shrestha, & Pant 2019). Students must first grasp mathematical concepts before they can solve problems, apply what they've learnt in the real world, and acquire mathematical skills—all of which are aims of learning Mathematics. Technology has an important part in a country's growth; in the modern world, technological improvement promotes both social and economic progress. Science and technology now serve as the key tools for power development. Nations such as China, Japan, the United States, and Russia are examples of developed countries due to their scientific and technological achievements. The Nigerian educational system encourages teachers to include information and communication technology (ICT) in their lesson. Incorporating ICT into mathematics instruction engages students at all levels (Bhagat & Chang (2015). When ICT is employed in mathematics instruction, it piques students' interest and promotes discovery learning. Students studying mathematics, particularly geometry, must be able to recall, generate, and grasp not only theoretical information but also practical applications of what they have learnt. Since then, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) has approved it. The ability to solve mathematical problems and memorize rules and formulas by memory are only two parts of mathematical knowledge; practical conceptual understanding and intuitive insight are also required for true mathematical learning. Its relevance extends beyond regular duties to cutting-edge scientific research and technology advances. Mathematical principles such as algebra, statistics, and probability are essential for project planning, data analysis, and financial budgeting.

According to Sabrun (2025), mathematical problem-solving is an important skill that promotes logical reasoning and helps people solve real – world problems in both personal and professional situations. Mathematics is the cornerstone of all technology. Computer science, engineering, and data science all rely on mathematical concepts such as algorithms, calculus, and linear algebra. These disciplines drive innovations that have an impact on modern civilization, such as artificial intelligence and cellphones. Mathematical research is built on technical developments, such as big data, machine learning, and cryptography, which push the boundaries. Furthermore, mathematics is crucial in medicine and wellbeing. Mathematics is essential for providing effective healthcare, from calculating prescription dosages to simulating the spread of diseases. For example, the management of public health during the COVID-19 outbreak was extensively reliant on mathematical modelling and biostatistics. Mathematical models have helped predict the spread of the virus, improve immunization strategies, and measure the efficacy of medicines.

Students' negative attitude towards Mathematics stems from their dread of the subject and their impression of it as difficult. It has been demonstrated that traditional teaching methods fall short of providing students with opportunities to increase their understanding of geometry concepts and build a positive attitude towards the topic (Jelatu, 2018). Consequently, the traditional approach is not as efficient as enhancing the cognitive skills of the students. For example, students frequently regard geometry as a difficult subject in mathematics and recall negative experiences with it (Le & Kim, 2017). Students have difficulty understanding mathematics because it involves working abstractly across several sub-content areas. In this sense, it is increasingly critical to make Mathematics instruction fun and to plan sessions using a variety of teaching strategies, tactics, and resources. The emergence of the COVID-19 pandemic led to the closure of schools in March 2020, which necessitated a swift transition to the online or home-based learning environment. This move presented a number of challenges for both students and instructors. The Nigerian educational system was unprepared for the extended shutdown caused by the COVID-19 outbreak. As a result, dynamic Mathematics software applications have become a key component of efforts to change Mathematics procedures.

The application of dynamic software in teaching mathematics is important to expose students to trials and errors, such that they are able to obtain hypotheses, generate assumptions and obtain conclusions based on findings by reflecting on themselves as mathematicians who make discoveries. The geometry learning area appears to be the most prominent of the Mathematics sub-learning areas where students can participate in these trial-and-error exercises. Geometry is a difficult subject to study due to its abstract conceptual structure and the need for advanced thinking skills from the learner (Uwurunkundo et al., 2022). Dynamic geometry software will help to spark this interest in geometry teaching. Some of these tools include GeoGebra, which is an open-source software that integrates geometry, algebra and analysis in one interface. Markus Hohenwarter created GeoGebra in 2002, A software program with the package including geometry, algebra and calculus in an easy-to-use open-source application. GeoGebra is a technological tool that encompasses all aspects of mathematics. The application includes a variety of interactive geometry teaching aids. It provides multiple representations. It combines a spreadsheet, algebra, and geometry in one. Use of computers in the classroom, especially through math software like GeoGebra, might enable the students to perform the calculations faster and might help in abstracting the math concepts.

The GeoGebra has been applied in teaching a vast variety of course units in the study of Mathematics calculus, trigonometry, statistics, algebra, and geometry. Some of the concepts of geometry include coordinate geometry, geometric transformation, analytic geometry, triangles, circles, circle theorem and polar coordinates. Interest exists in using information and communication technology (ICT) and the tools in the teaching of mathematics. The education experts said that being taught and learning mathematics through technology would enhance the capacity of students to envisage, think, reason, analyze, and explain coherently. Using computers, teachers can develop lessons that capture students' attention and passion for learning and loving mathematics. Although educational technology is more than important and much more advised about using it, traditional forms of teaching and learning mathematics are still employed in school today in Nigeria. This learning style is characterized by focus on the teacher over the learner. Due to this, children can compute, yet they do not have the mathematical knowledge and abilities that can enable them to encounter practical problems in the real world.

Several studies have revealed that GeoGebra is a good teaching and learning software in mathematics. GeoGebra has also been shown to raise student satisfaction, improve student relationships with their teacher, have positive effects on student attitudes to GeoGebra and coordinate geometry, improve test performance, and help students with visualizing difficulties. Investigations exploring GeoGebra's potential as an ICT tool to improve students' mathematical thinking indicated that it performs best when appropriately integrated into Mathematics instruction at all educational levels, beginning with primary school. The incorporation of ICT into science and mathematics teaching and learning has resulted in a substantial shift in educational quality and pedagogical approaches (Ratheeswari, 2018). It alters how students and teachers interact, as well as how topic knowledge is communicated (Nsabayezu et al., 2023a, 2023).

Benefits and Applications of GeoGebra Software

1. Free Software: The price and compatibility of GeoGebra make it free software that can be installed without any fee or subscription. Anyone with an internet connection can use GeoGebra for free, removing the financial barrier associated with acquiring instructional software.
2. Versatility: GeoGebra is a versatile program that addresses a wide range of mathematical disciplines, including algebra, calculus, statistics, and geometry. It simplifies learning for children by allowing professors to teach a variety of mathematical disciplines on a single platform. Furthermore, by accommodating pupils with varying comprehension levels, this adaptability aids differentiated instruction.

Coordinate geometry, often known as analytical geometry, is a branch of mathematics that explains and analyses geometric figures and their properties using algebraic equations. This area blends algebra and geometry by allowing for the algebraic solution of geometric problems using a coordinate system, most commonly the Cartesian system. Coordinate geometry is useful in many contexts. It has uses in engineering, architecture, athletics, art, and a variety of other professions. Some authorities define attitude towards Mathematics as simply a liking or hatred for Mathematics, but others broaden the definition to include beliefs, ability, and utility of Mathematics. According to Zan and Di Martino (2007), attitude towards mathematics merely relates to one's emotional disposition towards the subject, which might be positive or negative. However, Neale (1969) defines attitude towards Mathematics as the total of "a liking or disliking of Mathematics, a tendency to engage in or avoid mathematical activities, a belief that one is good or bad at Mathematics, and a belief that Mathematics is useful or useless" (p. 632). Among tech-savvy young people, the traditional talk-and-chalk teacher-centered education technique, which assumes pupils are passive consumers of knowledge, has lost popularity. It is considered that incorporating ICT, notably GeoGebra, into secondary school Mathematics instruction can serve as a foundation for better administration of curriculum changes and improvements.

Research Objectives:

The following objectives were used in this study:

1. Identify the impact of GeoGebra-aided teaching on the attitude of students to learning coordinate Geometry.
2. Examine the variation that is present between male and female students' attitudes towards the subject-Coordinate Geometry by use of GeoGebra.

Research Questions

1. What is the impact of instructional module GeoGebra-aided learning on students' attitude to learning coordinate Geometry?
2. What is the contrast between the attitude of the male and female students learning Coordinate Geometry with the help of GeoGebra?

Hypotheses

1. No difference is found in the students' attitudes towards Coordinate Geometry learning after being taught with GeoGebra.
2. A significant difference in the attitude of male and female SS 3 Mathematics students instructed using GeoGebra does not exist.

Material and Methods

The current research adopted a quasi-experimental research design that used a pretest-posttest control group model. The design entailed a comparison between the outcome of GeoGebra-assisted instructions (experimental group) and the traditional teaching technique (control group) towards the attitude toward coordinate Geometry using students as subjects. Quasi-experimental design is a somewhat real experiment where participants of the study are grouped. Three out of twenty-one schools in Warri South Local Government Area were purposively selected due to the availability of functional computers in the laboratory and proximity to researcher. Two schools (SS 3 intact Classes) were used as experimental group and the other school was used as control group. The sample size of 118 S.S.S 3 Mathematics students was conveniently chosen from the 3 schools because they were easily accessible and were already formed classes. The experimental group was exposed to an intervention whereby they were made to learn coordinate Geometry using GeoGebra software for five weeks, and the control group was made to learn coordinate Geometry using a traditional approach devoid of GeoGebra. The test-retest method was adopted to establish the instruments' reliability. The researcher used the instrument CGAI to test 20 students at different periods who are not going to participate in the current study, and the findings obtained. Cronbach's Alpha was used to determine reliability coefficients of 0.86 for the instrument coordinate Geometry attitude test (CGAI). The CGAI was coded from 4 points to 1 point on the likert scale. The average of 50 point is considered as positive attitude towards Geometry while less than 50 is considered as negative attitude towards Geometry. The obtained data were analyzed through descriptive statistics (Mean and Standard deviation) to identify answers to the research questions, whereas the hypotheses were tested using inferential statistics, Analysis of Covariance (ANCOVA) at a 0.05 level of significance.

Results

Research Question 1**:** How does GeoGebra-assisted instruction affect the attitude of students toward learning Coordinate Geometry?

Table 1: Mean and Standard Deviation of Students' Attitudes by Teaching Method

Methods		**Pretest Attitude level**	**Post Test Attitude Level**	**Mean Gain Attitude level**
GeoGebra	Mean	2.38	2.63	0.25
	Std. Deviation	2.20	2.20	
	N	65	65	
Lecture method	Mean	2.35	2.39	0.04
	Std. Deviation	3.89	3.89	
	N	53	53	

Table 1 compares students' attitude levels toward learning before and after exposure to two instructional methods: GeoGebra and the lecture method. The results reveal that students taught using GeoGebra had a pretest mean attitude level of 2.38 (SD = 2.20) and a posttest mean of 2.63 (SD = 2.20), indicating a mean gain of 0.25. Conversely, students exposed to the lecture method demonstrated a pretest mean attitude level of 2.35 (SD = 3.89) and a posttest mean of 2.39 (SD = 3.89), reflecting a smaller mean gain of 0.04. These findings suggest that the GeoGebra method resulted in a more notable improvement in students' attitudes compared to the lecture method.

Research Question 2: How does the attitude of teaching Coordinate Geometry vary through GeoGebra in male and female students?

Table 2: Mean and Standard Deviation of Students' Attitude by Gender

Gender		**Pretest Attitude**	**Post Test Attitude**	**Mean Gain (Attitude)**
Male	Mean	2.32	2.58	0.26
	Std. Deviation	0.17	0.17	
	N	30	30	
Female	Mean	2.43	2.67	0.24
	Std. Deviation	0.22	0.22	
	N	35	35	

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Table 2 shows the results in terms of the mean and standard deviation of the level of attitude means of the students in terms of gender at the pretest, the post-test and the mean gain in attitude. For male students (n=30), the mean attitude score went up from 2.32 (SD = 0.17) during the pretest to 2.58 (SD = 0.17) in the post-test, resulting in a mean gain of 0.26. Similarly, for female students (n=35), the mean attitude score went up from 2.43 (SD = 0.22) during the pretest to 2.67 (SD = 0.22) in the post-test with an average gain of 0. 24. These findings reveal that the attitude levels grew in both male and female students after the pretest-post-test exercise; and the mean gain in the males is narrowly ahead of that of the females.

Testing of Hypotheses

Hypothesis 1: No considerable effect on students' attitudes toward Coordinate Geometry learning after installing GeoGebra software.

Table 3: Summary of Analysis of Covariance of students' attitude based on methods using Pre - attitude as Covariate

Dependent Variable: **Post Attitude**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2.597[a]	2	1.299	61.158	.000	.614
Intercept	.447	1	.447	21.046	.000	.215
Pre-Attitude	1.433	1	1.433	67.486	.000	.467
Methods	.934	1	.934	43.965	.000	.363
Error	1.635	77	.021			
Total	514.428	80				
Corrected Total	4.232	79				

a. R Squared = .614 (Adjusted R Squared = .604)

Table 3 reveals a value of $F_{1,77} = 43.965$, p= .000 ($p < 0.05$), the difference in the mean attitude of SS 3 Mathematics students taught through the use of GeoGebra-computer-software and those taught in the traditional methods of instruction. The null hypothesis is thus rejected, and this report indicates that there is a significant difference between the mean attitude of students taught SS 3 Mathematics using GeoGebra software and those taught using the traditional methods of teaching.

Hypothesis 2: The attitude of male and female SS 3 Mathematics students instructed based on GeoGebra does not present a significant difference.

Table 4: Summary of Analysis of Covariance of students' attitude based ongender using Pre attitude as Covariate

Dependent Variable: Post Attitude

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.513[a]	2	.256	8.381	.001	.285
Intercept	.611	1	.611	19.975	.000	.322
Pre_Attitude	.430	1	.430	14.056	.001	.251
Gender	.014	1	.014	.442	.510	.010
Error	1.285	42	.031			
Total	313.473	45				
Corrected Total	1.798	44				

a. R Squared = .285 (Adjusted R Squared = .251)

Table 4 discloses a value of $F_{1,42} = 0.442$, p = .510 ($p > 0.05$) to determine the difference in the attitude of male and female SS 3 Mathematics learners taught through the use of GeoGebra. This means that the null hypothesis is accepted, and hence there is no significant difference in the attitude of male and female SS3 mathematics students taught with GeoGebra.

Discussion

This study finds a marked difference in attitude between students learning with GeoGebra software and with the standard methods of teaching. Table 1 shows that the mean gain of learners treated with the help of the GeoGebra method was higher than the traditional teaching method. Another factor confirming this great difference is the ANOVA results shown in Table 4, which show that there is a high possibility that a statistically significant difference in attitude will be found.

All these findings cumulatively indicate that the GeoGebra software is a good teaching tool in teaching Coordinate Geometry that may help in ensuring similar learning progress outcomes between male and female students. The slightly larger mean gain of male students in this experiment may be explained by context-related or individual differences, but it does not show a substantial gender-based difference in attitude towards using GeoGebra. This reinforces the versatility and inclusivity of GeoGebra as a gender-neutral instructional approach. The findings from the study reveal no significant gender-based differences in students' attitudes and interest in Coordinate Geometry when comparing the use of GeoGebra-assisted instruction to the conventional lecture method which could be due to prior exposure to technology by both gender.
These findings suggest that gender differences in attitude may vary depending on the specific mathematical topic or context of GeoGebra's application.

Conclusion
This research indicates that the GeoGebra-aided pedagogy will be able to help in changing the student attitude toward learning Coordinate Geometry positively. The method was shown to be more impactful than the conventional lecture method, fostering greater engagement and understanding among students. Even though male students had a little higher mean gain in attitudes than females did, the issue was statistically irrelevant, which indicates the high applicability of the method to both groups.

Recommendations
Recommendations are made about the findings of the study as presented below.

1. GeoGebra-assisted instruction should be used to teach Mathematics, particularly in subjects such as Coordinate Geometry, to increase understanding and engagement with students.
2. The teachers of Mathematics should be provided with professional development programs which would enable them to gain skills in using GeoGebra and other teaching devices based on technologies.
3. Curriculum planners should incorporate technology-based instructional methods like GeoGebra into Mathematics curricula to improve teaching and learning outcomes

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