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Development And Enhancement Of A Module For Teaching Geometry Thinking Skills Using Artificial Intelligence (AI) Among Senior Secondary School Students In Sokoto State, Nigeria

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ABSTRACT

This study focused on developing and enhancing a module for learning geometry thinking skills through Artificial Intelligence (AI) among senior secondary school students in Sokoto State. The objectives of the study include: assessing the level of interest in learning geometry using AI among senior secondary school students in Sokoto State; creating and advancing an AI-based instructional module to improve geometry learning; examining the difference in student performance before and after using the AI module in geometry; comparing the performance of students taught with AI to those taught using traditional methods in geometry; and evaluating students' abilities to solve geometry problems in both experimental and control groups before and after using the AI module. The study employed a two-group pre-test post-test quasi-experimental design, with a sample size of 379 students (200 boys and 179 girls) selected from a total population of 31,895 SS2 students in Sokoto State. The Ordinary Level Geometry Competence Achievement Test (OLGCAT) was used to measure the academic performance of the students in mathematics, based on the mathematics curriculum and study objectives. Data was analyzed using descriptive statistics, while hypotheses were tested using paired sample T-test and independent sample T-test. The study, which will be completed within seven months, aims to determine the positive impact of the AI-based geometry learning module on senior secondary school students in Sokoto State.

Keywords: Artificial Intelligence, geometry thinking skills, students

INTRODUCTION

Geometry is a branch of mathematics that focuses on the properties and relationships of shapes, sizes, figures, and the space they occupy. It is one of the oldest mathematical fields, originating from ancient civilizations like Egypt and Greece. Geometry involves the study of various shape elements, including points, lines, angles, surfaces, and solids (Kline, 2021). Key concepts in geometry include points (which have no dimension), lines (which extend infinitely in both directions), and planes (flat, two-dimensional surfaces). It also covers the properties of shapes such as triangles, circles, and polygons, analyzing their angles, sides, and symmetry (Katz, 2014).

According to Banchoff and Kuhn (2022), geometry is divided into two main branches: Euclidean and non-Euclidean. Euclidean geometry, named after the Greek mathematician Euclid, focuses on flat, two-dimensional spaces and serves as the foundation for most traditional geometry. Non-Euclidean geometries, such as spherical and hyperbolic geometry, deal with curved spaces and are used in advanced fields like physics and cosmology. Understanding geometry is crucial for developing spatial reasoning skills, which are essential in real-world applications such as architecture, engineering, computer graphics, and robotics (Coxeter & Greitzer, 2021).

Artificial Intelligence (AI) refers to the replication of human intelligence by machines. It involves creating algorithms and models that allow machines to perform tasks typically requiring human cognition, such as learning, reasoning, and problem-solving (Russell & Norvig, 2021). AI includes various technologies, like machine learning, where systems improve performance through experience, and natural language processing, which enables machines to understand and interact with human language (Goodfellow & Courville, 2016). AI has numerous applications, ranging from virtual assistants and recommendation systems to autonomous vehicles and healthcare diagnostic tools (Mitchell, 2019). By mimicking human intelligence, AI aims to increase efficiency and create new opportunities across various industries (Mikolov & Grave, 2021).

Ajinuhi and Onoge (2024) researched the use of AI in teaching and learning mathematics in tertiary institutions. Their study, which used secondary data from both print and online sources, concluded that integrating AI into mathematics programs significantly improves various aspects of teaching and learning, such as lecture presentation, student result reporting, development of smart content, automated simulations, and personalized learning experiences. The study advocates for further investment in AI integration within mathematics programs at tertiary institutions.

Fitria (2021) examined the growing influence of AI across sectors, including education, and highlighted its transformative role in subjects like technology, science, mathematics, and engineering. AI facilitates learning by allowing students to learn at their own pace, addressing their individual needs. It is believed that AI can improve learning outcomes and help achieve educational goals more effectively (Baker & Inventado, 2014). Despite concerns about AI replacing teachers, many argue that AI should complement, rather than replace, educators (Chen, 2019). Educators need to acquire skills in using AI for tasks such as lesson planning, attendance tracking, and creating educational resources. This study aims to explore the impact of AI on education, particularly in teaching and learning processes.

A module is a self-contained unit within a larger system designed to perform a specific function or deliver particular content. In educational contexts, modules refer to structured learning segments focused on specific topics or skills, such as curriculum units or online course components (Morrison & Lowther, 2019). Modules are flexible and can be adapted to fit different educational needs (Reigeluth & Carr-Chellman, 2009). They typically include instructional materials, exercises, assessments, and multimedia resources to support learning, helping students engage with and master content effectively (Gagne & Wager, 2004).

Traditional teaching methods refer to conventional approaches used in education before the widespread use of modern technology. These methods often rely on direct instruction, where teachers lecture and students practice concepts through exercises and assignments (Sloan, 2004). Traditional methods emphasize rote learning, memorization, and standardized testing (Cuban, 2001). These methods offer a systematic way to teach fundamental concepts but may lack the interactive and adaptive features that modern educational technologies provide (Brunner, 2010).

Thinking skills are cognitive abilities necessary for analyzing, evaluating, and creating ideas effectively (Paul & Elder, 2014). They include critical thinking, which involves assessing information and making reasoned judgments, and problem-solving, which involves finding solutions to complex issues (De Bono, 2015). Important thinking skills also include creative thinking (generating innovative ideas) and logical reasoning (ensuring structured and coherent thought processes) (Heath, 2010). Developing strong thinking skills enables individuals to approach challenges strategically, make informed decisions, and adapt to new situations (Willingham, 2009). These skills are crucial for academic success and are highly valued in personal and professional contexts.

Statement of the Problems

Global attention is increasingly focused on the challenges of teaching in the 21st century, particularly the need for adequate training and planning to integrate technology into education. In this context, Nigeria, as a developing country, still lags behind in utilizing technology for instructional purposes. The Nigerian government has stressed the importance of integrating technology into teaching and learning at all educational levels (Jo & Afolabi, 2023; Ogunyemi & Akinbode, 2022). However, despite its significance for national development, many Nigerian teachers are still unable to incorporate technology into their teaching. As a result, the integration of Artificial Intelligence (AI) into geometry instruction is becoming crucial for effective learning.

For years, traditional teaching methods, which heavily rely on abstract examples and verbal explanations, have dominated senior secondary schools in Nigeria. The Chief Examiner's report for the WAEC (2020) highlights several challenges in teaching and assessing geometry at this level. One major issue is the lack of conceptual understanding among students. Many students struggle with basic geometry concepts such as the unit circle, geometric functions, and their applications. The WAEC (2023) report also reveals poor performance in geometry, with many candidates lacking a solid understanding of key concepts like geometric identities and their applications. Contributing factors include insufficient preparation, limited exposure to practical problems, and inadequate classroom support. Similarly, the NECO (2023) report points to concerning trends of poor performance, including issues like inadequate preparation, lack of resources, and subpar teaching quality. The NECO (2022) report highlights a significant decline in students' performance in geometry, particularly with concepts like trigonometric functions and identities, which has led to high failure rates.

The integration of AI in geometry instruction is now seen as essential for improving the teaching and learning process. However, to maximize its benefits, AI must be properly implemented to improve learning outcomes. Traditional teaching methods that rely on abstract examples and verbal explanations are still prevalent at the secondary school level. In Sokoto, as in other regions, this approach leads to students encountering geometry content without grasping its relevance or practical applications, fostering a growing reluctance toward the subject and low proficiency levels. This is reflected in consistently poor performance in mathematics compared to other subjects. Additionally, there is a lack of technological integration, particularly AI, in geometry education in Sokoto. Teachers in the region seldom use AI, leading to a less dynamic and effective learning environment.

In Sokoto, there is a noticeable absence of technological integration in the teaching of geometry, with AI modules for learning remaining underutilized. The traditional teaching methods continue to dominate, which prevents students from understanding the real-world relevance and applications of geometry. This study aims to address these challenges by investigating the development and implementation of an AI-based module to enhance geometry thinking skills among senior secondary school students in Sokoto State.

Objectives of the Study

The aims of the study is to investigated the Creation and Advancement of Module for Learning Geometry Thinking Skills using Artificial Intelligence AI Among Senior Secondary School Students in Sokoto State. Specifically, this study has the following research objectives to:

(i) Find out the deference in the performance of senior secondary school students, in learning Geometry before and after using Artificial Intelligence AI module in sokoto State

(ii) Find out the performance of students taught before and after using Artificial Intelligence Module and traditional method on learning Geometry in secondary school in Sokoto Nigeria

Research Questions

On the basis of research questions raised the following research question bellow would be used in this study would intent to answer the following research question:

(i) Is there any deference in the performance of senior secondary school students, in learning Geometry before and after using Artificial Intelligence AI module in sokoto State ?

(ii) Is there any deference in the performance of students taught before and after using Artificial Intelligence Module and traditional method on learning Geometry in secondary school in

Sokoto Nigeria?

Research Hypothesis

On the basis of research questions raised the following null hypothesis bellow would be used in this study

(i) There is no statistically Significant Difference between the performance of senior secondary school students in Learning Geometrical Thinking Skills before and after using Artificial Intelligence module in sokoto State

(ii) There is no statistically Significant Difference in the performance of students taught before and after using Artificial Intelligence Module and traditional method on learning Geometry in secondary school in Sokoto? Nigeria

METHODOLOGY

This section discusses the methodology applied in this study. In particular, the chapter gives attention to the following aspects: research design, population of the study, sampling and sampling techniques, instrument for data collection, data collection procedures, and data analysis.

Research Design

This study employed a quasi-experimental design, specifically a two-group pre-test post-test design. The research involves two groups: the experimental group and the control group (Creswell, 2012). In this design, the students' geometry competence is assessed before the treatment. The class is divided into two groups: the experimental group, which is taught using AI, and the control group, which is taught using traditional teaching methods. Any differences observed between the two groups (experimental and control) are attributed to the manipulation of AI. The table below summarizes the design of the study:

Table 1. Research Design of the Study

Group	Pre-Test (Ya)	Treatment	Post-Test (Yb)
Experimental Group (EG)	OLGCAT	Student centered dynamic experiential learning environment using ICT equipment for learning mathematics	OLGCAT
Control Group (CG)	OLGCAT	Student centered dynamic experiential learning environment using Traditional method of learning geometry i.e paper and pencils.	OLGCAT

Source: (primary data, 2025)

Population and Sample

Mathematics is a mandatory subject for all senior secondary school students in Sokoto State and is considered a crucial period for students to acquire foundational mathematical knowledge (Federal Republic of Nigeria, 2014; Usman & Mohammed, 2020). The target population for this study consists of 31,895 senior secondary school students in Sokoto State. However, the study specifically focuses on SS II students.

Table 2 Distribution of the Population

Class	Respondents	Population
SS II	Students	31,895
Total		31,895

(Source: MOE Sokoto 2024)

Research Instrument

In order to measure academic achievement of the sample students in the subject of mathematics a teacher made geometry test (OLGCAT) is administer immediately before and after completing the experiment

teaching to both the groups, in the schools at the same time and data collect Is the scores of students achieved in the both pre-test and post- test. The Researcher made a thorough study of geometry taught and techniques of test construction. Test is prepare by the experience math teachers at secondary level, and higher institution from the topics taught to both the groups by making the chart of specification, and by considering the technique of paper setting for different understandings, i.e. 10% for difficulty, 75% for average, and15% for easy levels. The test contained 20 items as a whole, questions is objectives and five questions essay, since all these types of testing is included in the syllabus. Time duration for the test was fixed as one and a half hour, which is considered to be appropriate for the completion of the test for both the groups. In addition post-test was conducted on the same day and time.

Population of the Study

Mathematics is a mandatory subject for all senior secondary school students in Sokoto State and is considered a crucial period for students to acquire foundational mathematical knowledge (Federal Republic of Nigeria, 2014; Usman & Mohammed, 2020). The target population for this study consists of 31,895 senior secondary school students in Sokoto State. However, the study specifically focuses on SS II students. are given in the table 3.1

Table 3 Distribution of Schools in Sokoto State on Zonal Basis.

S/N	ZONE	MALE	FEMALE	MIXED	TOTAL
1	Sokoto North A	11	5	1	17
2	Sokoto South B	26	8	1	35
3	Gwadabawa C	16	4	-	20
4	Bodinga D	17	4	-	21
5	Goronyo E	21	4	-	25
6	Yabo F	17	7	-	24
	TOTAL	108	32	2	142

Source: Ministry of Education (2024)

Sample and Sampling Technique

The study utilized a sampling approach based on Morgan and Kreycie's (1971) table to determine the appropriate sample size from a given population. A total of six Senior Secondary Schools were selected using a fish-bowl random sampling technique. In this method, each school's name was written on a slip of paper, placed in a container, mixed thoroughly, and drawn without looking. Each selected slip was returned to the container, and the process was repeated until six schools will be chosen from the 142 schools listed in the zonal education offices of Sokoto State.

For this study, simple random sampling is utilized to select participants. This method ensures that every member of the population have an equal chance of being included in the study, which investigates the design and development of a module for teaching trigonometric thinking skills using Microsoft Mathematics among senior secondary school students in Sokoto State, Nigeria (Khan, & Shah, 2022).

Simple random sampling is used to selected respondents of this study hope to give information regarding Creation and Advancement of Module for Learning Geometry Thinking Skills using Artificial Intelligence AI Among Senior Secondary School Students. This is simple sample where by all the members of the population stands equal chance to be chosen (Kumar, 2019: Leedy, & Ormrod, 2019).

Once the schools was selected, random sampling is use to choose students from these institutions. As outlined by Best and Kahn (1986), random sampling provides each individual in the population an equal and independent chance of being included. For the tests, only one class from the SS 2 level at each of the sampled schools participated.

The sample consisted of 379 students, comprising 200 boys and 179 girls, drawn from a total population of 31,895 SS 2 students in Sokoto State. The number of students selected per school adhered to the sample size recommendations from Morgan and Kreycie (1970). Given the total population of approximately 32,000 students, the table suggested a sample size of 379 students. Details on the distribution of male and female students, as well as the total number, are provided in the table below.

Table 4 Distribution of Students per Sample School

S/N	Name of School	Number of Male	Number of Female	Total
1	Sultan Bello Secondary School Sokoto	80	-	80
2	Government Day Secondary School Kofar Rini	70	-	70
3	Government Science Secondary School yabo	50	-	50
4	Government Girls Model Secondary School Illela	-	67	67
5	Government Girls Unity Secondary School Bodinga	-	67	67
6	Gamji Girls College Rabah	-	50	50
Total		200	179	379

Research Instruments for Data Collection

To assess the academic achievement of the sample students in mathematics, a researcher-designed geometry test (OLGCAT) was administered both before and after the experimental teaching to both groups at the same time in their schools. The data collected consisted of the students' scores from the pre-test and post-test. The researcher conducted a thorough review of the geometry content and test construction techniques. The test was created by experienced mathematics teachers at the secondary and higher education levels, based on the topics taught to both groups. A specification chart was used in preparing the test, with a focus on varying difficulty levels: 10% for difficult, 75% for average, and 15% for easy questions. The test consisted of 20 objective items, and five questions essay, as these types of questions are included in the syllabus. The test duration was set to one and a half hours, which was deemed sufficient for both groups to complete it. Additionally, the post-test was conducted on the same day and time.

Reliability of the Instruments

To determine the reliability of the instrument, a pilot test was conducted. This test included 20 items from the Ordinary Level Geometry Competence Achievement Test (OLGCAT), which were randomly distributed to senior secondary students. The items were combined into a single variable, and Cronbach's alpha was used to assess the reliability of the constructs using SPSS software. Cronbach's alpha measures the internal consistency of an instrument (Cronbach, 1984).

Method of Data Collection

At the end of the six-week experiment, the Ordinary Level Geometry Competence Achievement Test (OLGCAT) was administered to both groups at the same time. The test scores for each group were recorded separately and used to assess academic achievement, which was then analyzed statistically to meet the objectives of the study.

Procedure of Data Collection

The researcher obtained a formal introduction letter from the Head of the Department of Mathematics at Shehu Shagari College of Education, Sokoto, which was then presented to the Honorable Commissioner of the Ministry of Basic and Secondary Education in Sokoto. Following this, the researcher met with school principals and ICT lab tutors to discuss the research and obtain approval. After receiving permission, the researcher met with the relevant classes, explained the research goals, and sought consent for participation. Research assistants (ICT tutors) were recruited to help with data collection, and cognitive tests were conducted in the classroom.

Method of Data Analysis

After data collection, the quantitative data was edited, coded, and scored using SPSS software. The analysis was divided into four sections. The first section involved analyzing the demographic characteristics of the participants using percentages. The second section focused on analyzing the results of the OLGCAT. An Independent Sample T-test was used to compare the mean scores between the two groups, based on the study's specific objectives and hypotheses. This test was chosen to compare continuous variables between two groups (Khan & Shah, 2022). SPSS version 23.0 was used for all statistical calculations.

Research Procedure

The researcher and the computer teacher provided a three-day orientation for the experimental group, giving hands-on experience with computers during break times before the experiment began. As the students were already familiar with computers, the orientation focused on the specific requirements of the experiment, including email use, chatting, and Artificial Intelligence. Email addresses were created for the students and shared with their teacher. Students were trained to compose mathematical questions, send and receive emails, and access online resources. The orientation also included demonstrations of various global mathematics teaching resources. At the end of the orientation, the researcher and teachers assessed the students' understanding of the computer and software through oral questions.

Experimental Group

The experimental group received instruction using information and communication technology (ICT), specifically computers equipped with AI. Each student had access to a computer connected to software controlled by the teacher. Relevant trigonometry solver programs were downloaded from the software for convenience. The teacher clarified concepts using both the textbook and the software and encouraged students to use the software and online resources for further practice. Students used the software for problem-solving, communicated via email, and accessed online tutoring for assignments. They were also trained to create and use email addresses for academic communication.

DISCUSSION OF FINDING

This chapter presents the analyses and discussions of the study findings. The findings are presented based on the research questions and objectives of the study after elaborating on the descriptive data of the creation and advancement of the module for learning geometry thinking skills using artificial intelligence (AI) among senior secondary school students. All the findings are discussed in contrast with the findings of other researchers in various studies. This chapter is divided into three sections: the first presents descriptive statistics of the data, the second presents the quantitative results, and the last summarizes and discusses the research findings. The focus of this study was to explore the creation and advancement of a module for learning geometry thinking skills using AI among senior secondary school students in Sokoto State, Nigeria, and to compare the students' performance in mathematics to traditional teaching methods. The mean scores of the experimental and control groups, as measured by the post-test taken immediately after the completion of the experiment, were recorded. The equivalence of the experimental and control groups was assessed based on the scores from the previous achievement test in mathematics, using a t-test. The significance of the difference between the mean scores of the experimental and control groups was investigated by applying an independent sample t-test.

Demographic Data of The Students

This section analyzed demographic data of the students who participated in the study which comprised their sex and age.

Table 5. Showing the Sex of the Students

Sex of Respondents

sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	200	52.8	52.8	52.8
	Female	179	47.2	47.2	100.0
	Total	379	100.0	100.0	

Source: Field Data 2025

The table 5 above reveals that the highest number of students involved in this study were male with 200 representing (52.8%), this was followed by female who were 179 (47.2%), the difference between the male and female was quite negligible and this implied that both the male and female respondents responded positively towards the geometry learning.

Figure 1 Bar chart shows the sex of respondents

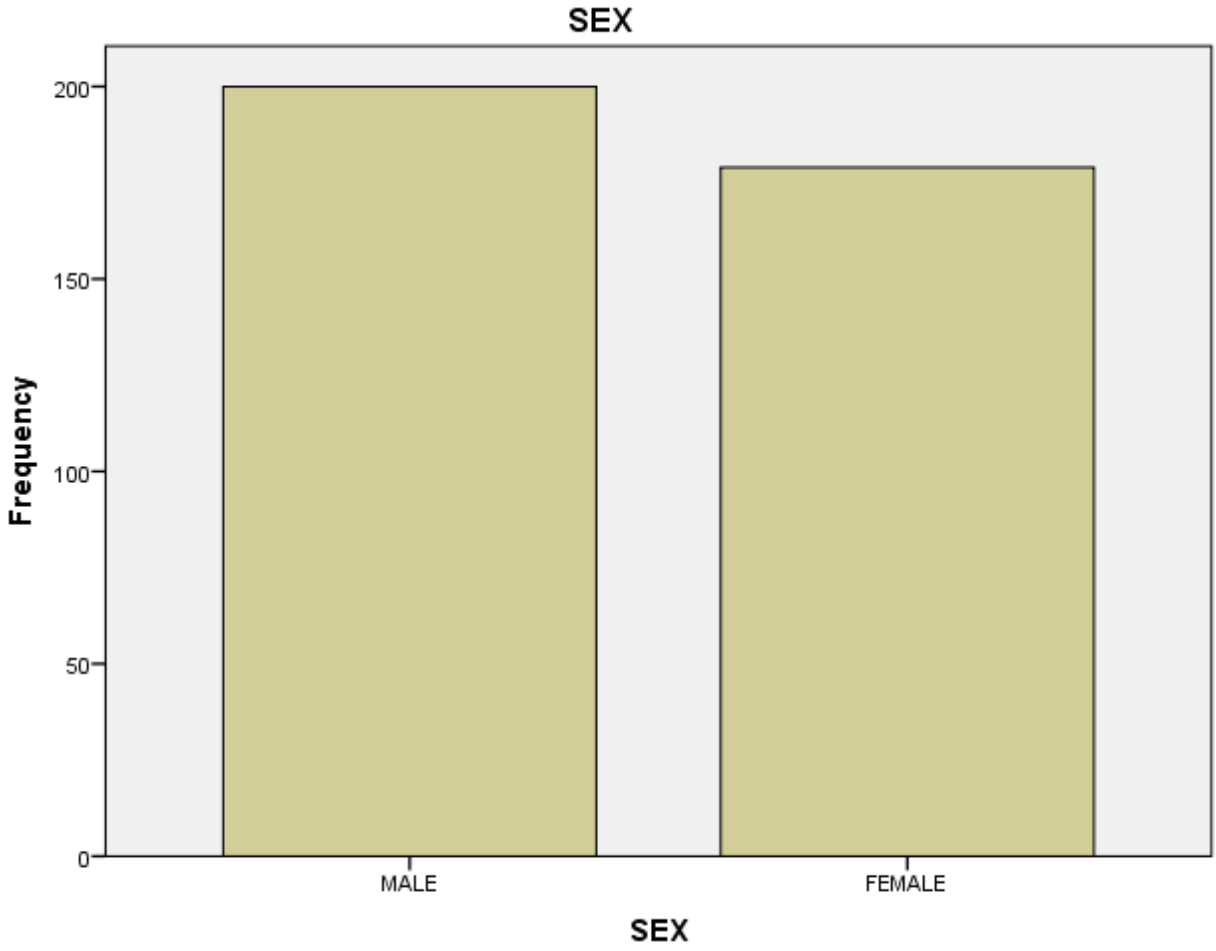


Table 6 Showing the Age Distribution of the Students

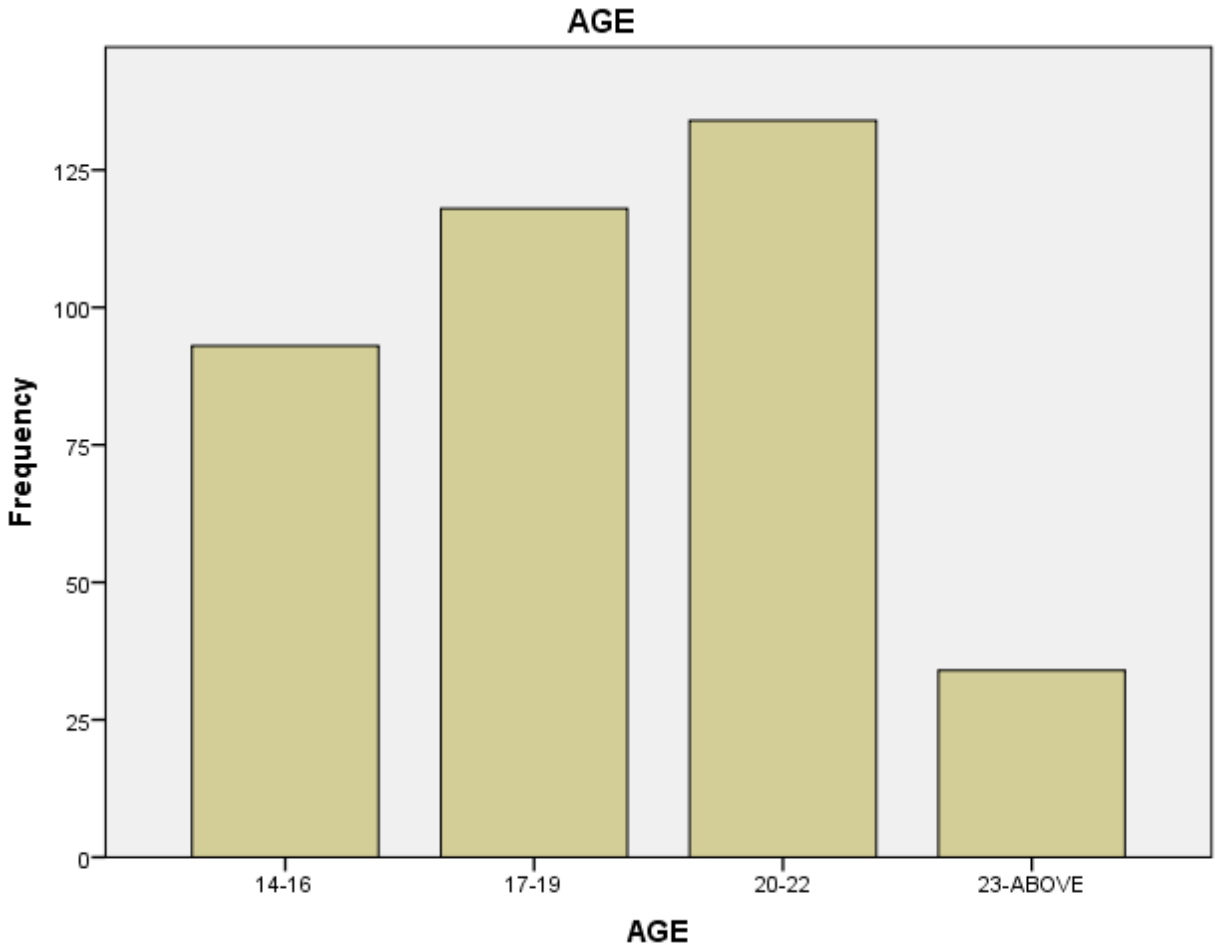
AGE

	Frequency	Percent	Valid Percent	Cumulative Percent
14-16	93	24.4	24.4	24.5
17-19	118	31.0	31.0	55.7
20-22	134	35.2	35.2	91.0
23-ABOVE	34	8.9	8.9	100.0
Total	379	99.5	100.0	
	379	100.0		

Source: Field Data 22025

Based on the result presented in table 6, it was indicated that 93 (24.4%) of the students were 14- 16years of age this was followed by 118 (31%) of the students were in the range of 17-19 years. 134 (35.2%) of the students were 220- 22 years of age while 34 (8.9%) of the students were in the range of 23 years above. Given the fact that majority of the students were of age, it suggested the fact that data were collected from true representatives of senior secondary school students in sokoto . This is in line with the

demographic analysis of Ibrahim (2015) who reported that majority of secondary school students in Mbale municipality were between the ages of 13-19 years.



Presentation of Research Hypotheses

The analysis is guided by the research hypothesis one:

Research Hypothesis

On the basis of research questions raised the following null hypothesis bellow would be used in this study

Research Hypothesis

(iii) There is no statistically Significant Difference between the performance of senior secondary school students in Learning Geometrical Thinking Skills before and after using Artificial Intelligence module in Sokoto State

In order to test the above hypothesis, the collected data was analyzed using paired t- test to determine the creation and advancement of module for learning geometry thinking skills using artificial intelligence (AI) among senior secondary school students in Sokoto state.

Table 7: T-Test the performance of senior secondary school students in Learning Geometrical Thinking Skills before and after using Artificial Intelligence module in Sokoto State (Paired Samples Statistics)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PRETESTEXP	21.9000	200	9.17666	.64889
	POSTTEXEX	66.2400	200	11.54290	.81621

Source: Field data, 2025

As indicated in table 7 the mean score of students in experimental group before the intervention was 21.9 and SD 9.177 Compared to mean knowledge score of students after the intervention 66.2 and SD 11.542, the students score was higher after the intervention.. The descriptive statistics highlight that creation and advancement of module for learning geometry thinking skills using artificial intelligence (AI) among senior secondary school students in sokoto state improved significantly after the intervention.

Table 8: T-Test the performance of senior secondary school students in Learning Geometrical Thinking Skills before and after using Artificial Intelligence module in sokoto State (Paired Samples Statistics)

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PRETESTEXP - POSTTEXEX	-44.34000	14.47973	1.02387	-46.35903	-42.32097	-43.306	199	.000

The paired t-test statistic in table 4.4 reveals that there is a statistically significant difference between pre and post intervention scores of learning $t(199) = 43.306$, $p < 0.05$). Therefore, the null hypothesis was rejected. Hence, AI is effective in improving the learning scores geometry students. The eta squared statistics (95%) indicated a large effect size. (Cohen ,1988) considering this, it was therefore conclude that performance of senior secondary school students in Learning Geometrical Thinking Skills before and after using Artificial Intelligence module in Sokoto State has positive effect on students academic achievement in geometry among the senior secondary schools students in Sokoto state.

The finding of this study is in agreement with the views of Golgenberg (2000:1) who points out that one of the strongest forces in the contemporary growth and evolution of mathematics and mathematics teaching is the power of new technologies.

The finding of this study is also in agreement with findings of Hennessy *et al., (*2001) Technological tools allow students to learn matrices, set and statistics more easily, quickly and accurately; to manipulate the graphs; and to develop generalizations about the functions. More time can be spent on analyzing the graphs and less time on the actual development of the graphs. Students build deeper understanding of functions and the graphs of the functions since less time is spent performing calculations. In the study of comparison of knowledge gain for Pomerantz (in Dreiling, 2007:2) notes that "By reducing the time that, in the past, was spent on learning and performing tedious paper-and-pencil geometry use today allows students and teachers to spend more time developing mathematical understanding, reasoning, number

sense, and applications.

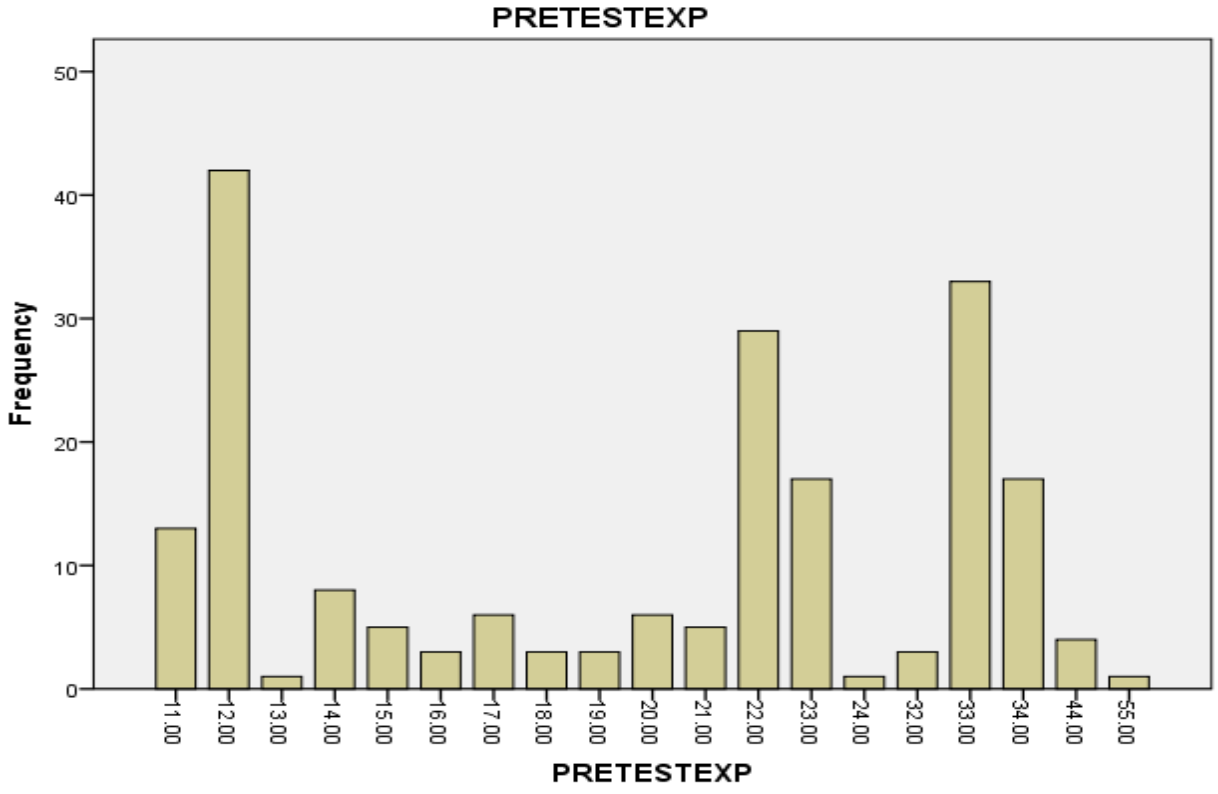
The finding of this study is also in agreement with findings of NCTM (2003), technological tools can increase both the scope of the mathematical content and the range of the problem situations that are within students' reach. Powerful tools for computation, construction and visual representation offer students access to mathematical content and contexts that would otherwise be too complex for them to explore.

The finding of this study is also in agreement with findings of Technology can enable students to explore relevant mathematical ideas through constructivist methods (Pugalee, 2001). It serves students as an information resource, a learning tool or a storage device that can support students to construct their own mathematical knowledge.

The finding of this study is also in agreement with findings of (Nicaise & Barnes, 1996:207) and allows students to actively participate and be responsible for their own learning. Technology supports exploration, which helps students set achievable goals, form and test hypotheses and makes discoveries of their own (Collins, 1991). In an environment where technologies are available, students might be involved in running experiments, testing conjectures, solving and posing problems and exchanging ideas.

In summary the findings on the study effect AI in learning geometry scores significantly improved after treatment, the test statistics revealed statistically significant difference that leads to rejection of the hypothesis and conclude there is significant difference in There is no statistically Significant Difference between the performance of senior secondary school students in Learning Geometrical Thinking Skills before and after using Artificial Intelligence module intervention.

Figure 1 Barchart shows the performance of students during pre-Test of experimental group



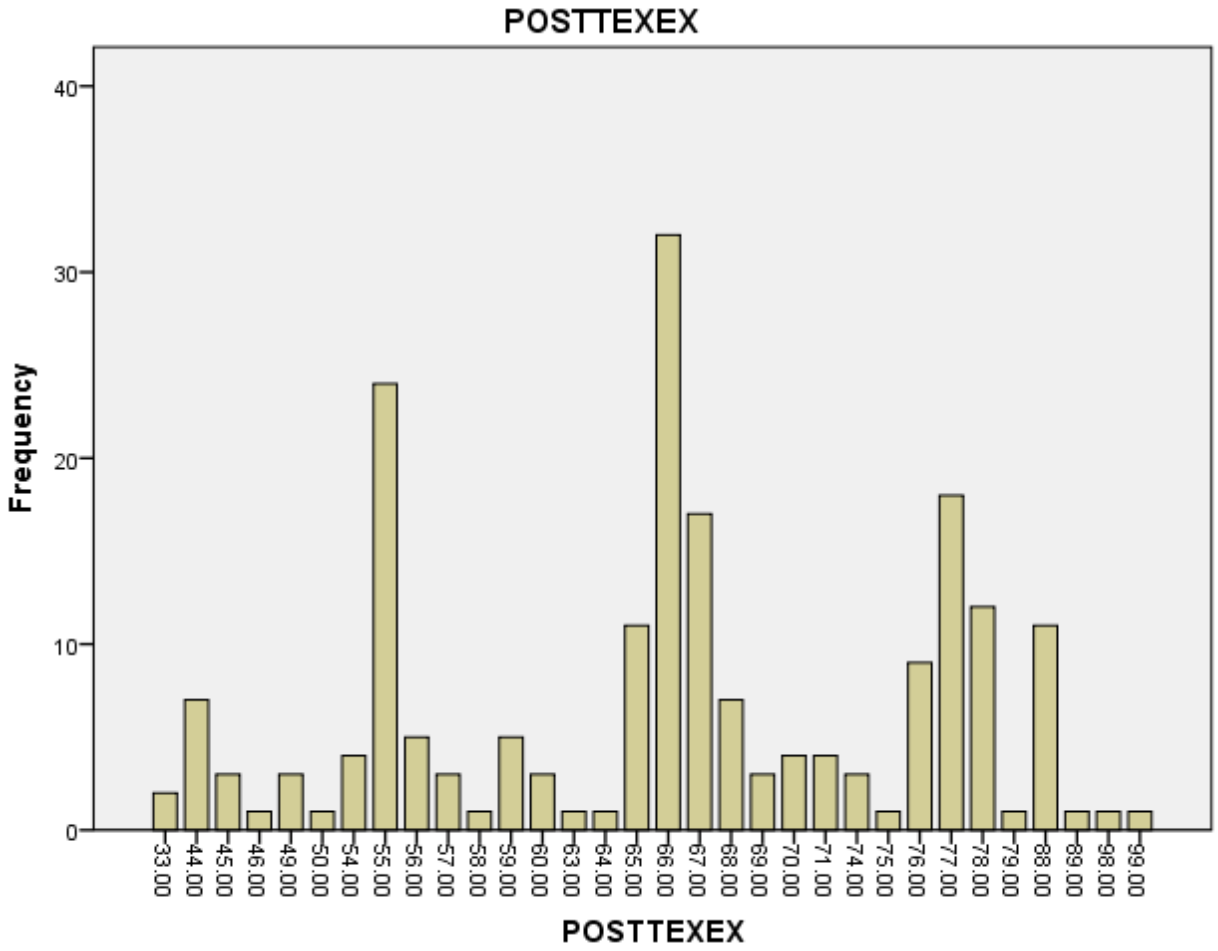


Figure 2 Barchart shows the performance of students during Post-Test of experimental group

Research Hypothesis Two There is no statistically Significant Difference in the performance of students taught before and after using Artificial Intelligence Module and traditional method on learning Geometry in secondary school in Sokoto

In order to test the above hypothesis, the collected data was analyzed using Independent sample T- Test to determine the effect of AI on learning geometry

Table 9 in the performance of students taught before and after using Artificial Intelligence Module and traditional method on learning Geometry in secondary school in Sokoto

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	POSTTEXEX	65.1564	200	11.13442	.83223
	POSTTESTC	47.9385	179	9.89561	.73963

As indicated in table 9 independent sample T-Test was used to determine if the post Test scores of Sokoto state students in experimental and control groups differed significantly. The results as illustrated in table

4.7 above show the mean scores and standard deviation of the mean scores and standard deviation of 65.15 ± 11.13442and 47.9385± 9.89561for experimental group and control group respectively. The mean standard error of the experimental post test (8.322) is higher than the mean standard error of the control post test (7.396).

Table 10 There is no statistically Significant Difference in the performance of students taught before and after using Artificial Intelligence Module and traditional method on learning Geometry in secondary school in Sokoto.

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
POSTTEXEX - POSTTESTC	17.47486	14.42077	1.07786	15.34783	19.60189	16.213	178	.000

Source: Field Survey 2025

Considering the result of independent t-test in table 10 t (178) 16.213 P < 0.05), the null hypothesis was rejected. Therefore, there is statistically significant difference in mean scores of students in experimental and traditional teaching method after the intervention. Meaning the experimental group performed better than the control group which shows ICT has more effect after the intervention. . The eta squared statistics (95%) indicated a large effect size. (cohen ,2002) considering this, it was therefore conclude that Post Scores on Experimental group and control group on learning mathematics positively affect students' academic the performance of students taught before and after using Artificial Intelligence Module and traditional method on learning Geometry in secondary school in Sokoto The finding of this study is in agreement with the views of generalizations (Wiest, 2000). Karatas, (2011) contends that technology motivates students to become more interested in exploring, investigating, conjecturing, creating, and discovering principles and making generalizations; it helps students in becoming mathematical problem-solvers, and in enhancing their conceptual understanding of mathematics.

The finding of this study is also agreement with the views of (NCTM, 2000). Therefore, the teachers may develop this skill when they learn how to use technology during pre-service education. The main purpose of using technology in teacher education is to enhance teacher‘s effectiveness and improve student‘s learning. Thus, appropriate training of teachers is very important.

CONCLUSIONS

In conclusion, the creation and advancement of a module for learning geometry thinking skills using Artificial Intelligence (AI) holds significant potential to transform the educational landscape for senior secondary school students. By leveraging AI, we can offer personalized learning experiences, allowing each student to progress at their own pace while receiving targeted feedback and support. AI-driven interactive tools and simulations can make abstract geometric concepts more tangible, helping students visualize and manipulate shapes and their properties in real time.

Moreover, the integration of adaptive learning paths and gamified elements can enhance engagement, motivation, and mastery of geometry concepts. AI's ability to assess student performance continuously and provide instant feedback fosters an environment of continuous improvement and mastery learning. This approach also empowers teachers with valuable insights into each student's strengths and areas needing attention, enabling more effective instruction.

Ultimately, AI can bridge the gap between traditional teaching methods and modern technological advancements, making geometry more accessible, engaging, and effective for students. The ongoing development of AI-powered learning modules promises to cultivate deeper geometric thinking, critical problem-solving skills, and a lifelong appreciation for mathematics, preparing students for future challenges in academia and beyond.

The study concluded that both experimental and traditional group scores significantly improved after the intervention. Also, learning geometry significantly improved after the experimental and traditional intervention.

The study similarly concluded that the experimental group performs better than the traditional group which shows AI has more effect after the intervention.

RECOMMENDATIONS

Here are Recommendations for the creation and advancement of a module for learning geometry thinking skills using Artificial Intelligence (AI) among senior secondary school students:

1. Personalized Learning Paths: Use AI to create adaptive learning paths based on individual student progress and understanding of geometric concepts.
2. Interactive Visualizations: Implement AI-driven interactive visualizations that help students manipulate geometric objects and explore properties in 2D and 3D space.
3. Real-time Feedback: Develop a system where AI gives real-time feedback on students' geometric problem-solving approaches, identifying errors and offering hints.
4. Concept Mapping: AI can help create dynamic concept maps that show how various geometric concepts are interlinked and suggest areas for improvement.
5. Progressive Difficulty Levels: Design tasks that increase in difficulty as students' geometric thinking skills improve, powered by AI to monitor and adjust difficulty.
6. Gamification: Integrate AI-powered gamification elements like levels, badges, and challenges to motivate students in learning geometry.
7. Step-by-Step Problem Solving: Incorporate AI tools that break down complex geometric problems into smaller, manageable steps, helping students understand the process.
8. Virtual Geometry Tutor: AI-based chatbots or virtual assistants could help students ask questions and receive instant explanations or hints about geometric concepts.
9. AI-driven Geometry Puzzles: Create AI-generated puzzles or real-life geometry applications that students can solve, aiding in practical learning.
10. Data-Driven Insights: Use AI to track student performance and provide insights on specific areas where they need improvement in geometry.
11. Dynamic Geometry Lessons: Create geometry lessons that adapt based on student input and performance, incorporating AI tools for automatic content generation.
12. Scenario-Based Learning: Use AI to generate real-world scenarios where students can apply geometry concepts (e.g., architecture, design, navigation).
13. Interactive Simulations: Develop AI-assisted simulations that allow students to interact with geometric shapes in various contexts, such as rotation, reflection, and scaling.
14. Multiple Representations: Allow students to explore geometry problems through different formats (graphs, diagrams, equations), aided by AI in transforming representations.
15. Real-World Geometry Problems: Integrate AI-driven, real-world geometry problems to show how geometry is applied in various fields like engineering, robotics, and art.

The application of AI was found effective for learning mathematics at secondary level. To make its application more effective in education, students should be trained in AI from the grass root level. Therefore, it is recommended that Information and communication technology (ICT) should be introduced as a separate discipline in the curricula of Nigeria from primary level.

Application of AI as a teaching strategy in mathematics was found effective as compared to traditional method of teaching. So to enhance its use in other disciplines of education, AI should be taught as a subject and it should be integrated into all other subjects of the curricula at secondary and higher secondary levels.

Considering the slight improvement on student learning after traditional teaching signifies students can learn also through traditional teaching however the researcher recommends combination of the two methods to

ensure maximum learning.

Policy makers and curriculum designers should endeavor to integrate 'O' level curriculum and find the different types of software and learning style that are most effective for use with computer education.

Suggestion for Further Research

(i) Further research on creation and advancement of module for learning geometry thinking skills using artificial intelligence (AI) among senior secondary school students using Solomon four group experimental design.

(ii) There is need to Research on development and enhancement of a module for teaching geometry thinking skills using artificial intelligence (AI) among senior secondary school students using two different schools.

(iii) There is need to investigate the development and enhancement of a module for teaching geometry thinking skills using artificial intelligence (AI) at university level. Since the study is focused on secondary school.

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