

Effect of Artificial Intelligence Tools on Teaching Effectiveness of Geometry in Tertiary Institutions in Benue State

Ako, Benjamin Tavershima¹; Tyav, Orya Herbert²

¹Department Of Integrated Science Education,
School of Secondary Education (Sciences)
College of Education, P. M. B. 2008, Katsina-Ala, Benue State, Nigeria

²Department Of Mathematics Education,
School of Secondary Education (Sciences),
College of Education, P. M. B. 2008, Katsina- Ala, Benue State, Nigeria

Corresponding E-mail Address: linkbenakoh@gmail.com

Phone: 08078787514, 07037415858

<https://doi.org/10.56201/wjimt.v10.no9.2026.pg97.110>

Abstract

This study examined the effect of Artificial Intelligence (AI) tools on teaching effectiveness of geometry in tertiary institutions in Benue State, Nigeria. A cross-sectional survey design was adopted. The study involved 235 respondents comprising 60 mathematics lecturers and 175 undergraduate students selected from state-owned tertiary institutions across the three educational zones of the State. Data were collected using a structured questionnaire and analysed using descriptive statistics and multiple regression at the 0.05 significance level. Findings showed a moderate-to-high extent of AI tool usage in geometry instruction (Grand Mean = 3.08). AI tool usage significantly predicted effective teaching of geometry ($\beta = .612, p < .001$), student engagement ($\beta = .641, p < .001$), and assessment and feedback practices ($\beta = .628, p < .001$). The models explained 45.0%, 42.8% and 42.1% of the respective variations. Major challenges included inadequate infrastructure, insufficient lecturer training and unclear institutional policies. The study concludes that AI tools can strengthen geometry teaching, student engagement, and assessment practices when appropriately integrated with lecturers' professional judgement. It recommends improved ICT infrastructure, continuous lecturer training, clear institutional AI policies, and responsible integration of AI into geometry instruction.

Keywords: Artificial Intelligence, Geometry Education, Teaching Effectiveness, Student Engagement, Assessment, Feedback, Tertiary Institutions.

1.0 Introduction

Mathematics remains a fundamental component of tertiary education, with Geometry occupying a particularly important position because of its contribution to spatial reasoning, logical deduction, abstraction, construction, and analytical thinking (Awang et al., 2025; Luckin et al., 2016). At the tertiary level, Geometry extends beyond elementary plane figures to include transformations, vectors, coordinate and analytic geometry, non-Euclidean systems, and mathematical proof, many of which present significant conceptual and cognitive challenges to learners (McGalliard & Otten, 2025). Its importance also extends beyond mathematics, as geometric knowledge is fundamental to disciplines such as engineering, physics, architecture, computer science, and other applied

sciences (Akintade et al., 2024). Despite its importance, the teaching and learning of Geometry at the tertiary level is often characterized by considerable challenges. Conventional approaches commonly rely on lectures, chalk-and-talk demonstrations, static diagrams, pencil-and-paper exercises, and memorization of geometric facts and procedures. Such approaches may inadequately address differences in students' spatial reasoning abilities, learning preferences, motivation, and capacity to visualize geometric shapes, relationships, and movements (McGalliard & Otten, 2025; Akintade et al., 2024). Consequently, students may acquire procedural knowledge without developing a deep conceptual understanding of geometric principles and their applications. The emergence of Artificial Intelligence (AI) in education provides new possibilities for addressing some of these challenges. AI refers to computational technologies capable of performing tasks associated with human cognitive processes, including pattern recognition, natural language processing, problem-solving, adaptation, and decision-making (Awang et al., 2025; Opesemowo & Ndlovu, 2024). In mathematics education, AI applications include intelligent tutoring systems, automated assessment and grading, conversational tutors, adaptive learning platforms, animated visualizations, and predictive learning analytics (Mohamed et al., 2022; Opesemowo & Ndlovu, 2024). The application of AI to Geometry instruction offers opportunities that conventional textbooks and static teaching methods may not provide. AI-enabled learning environments can facilitate interactive exploration, adaptive scaffolding, visualization of abstract concepts, immediate feedback, error diagnosis, and individualized learning experiences (Mohamed et al., 2022; Zawacki-Richter et al., 2019). Through interactive geometric activities, students can manipulate figures, test conjectures, explore relationships, visualize proofs, make deductions, and receive immediate guidance. These capabilities have the potential to reduce cognitive difficulties associated with abstract geometric concepts while promoting active and meaningful learning. Teaching effectiveness in Geometry depends on lecturers' ability to present spatial and conceptual ideas clearly, stimulate students' mathematical reasoning, assess their understanding, and facilitate deeper conceptual development. It also requires strong subject-matter knowledge and appropriate pedagogical strategies for helping students visualize geometric relationships and participate actively in learning (McGalliard & Otten, 2025). However, lecturers' effectiveness may be constrained by limited instructional time, large class sizes, the abstract nature of geometric concepts, inadequate instructional resources, and students' low motivation (McGalliard & Otten, 2025). These challenges create a need for innovative instructional approaches capable of supporting both lecturers and students.

The growing use of AI-powered educational technologies has therefore generated considerable interest in their potential to transform mathematics instruction. Existing evidence suggests that AI-supported teaching can enhance student engagement, conceptual understanding, problem-solving, feedback, and motivation (Walter, 2024; Holmes et al., 2022; Opesemowo & Ndlovu, 2024). However, the effectiveness of AI in Geometry teaching remains insufficiently investigated, particularly in developing educational contexts. Concerns have also been raised about excessive dependence on automation, reduced lecturer autonomy, ethical issues, technological limitations, and inadequate institutional infrastructure (Walter, 2024; Ayanwale et al., 2024).

These concerns are particularly relevant to tertiary institutions in Benue State, where large classes, inadequate instructional materials, varying levels of digital competence, limited technological infrastructure, and differences in lecturers' exposure to ICT may affect the adoption and effective use of AI tools. The successful integration of AI requires not only access to technology but also lecturers' technological proficiency, institutional support, professional development, reliable internet connectivity, and alignment between AI applications and curriculum objectives (Yue et

al., 2024). Where these conditions are inadequate, AI may be underutilized or fail to produce meaningful improvements in teaching effectiveness.

Given the persistent challenges associated with Geometry instruction and the growing availability of AI technologies, there is a need for empirical investigation into their role in tertiary education. Examining the effect of AI tools on the teaching effectiveness of Geometry in tertiary institutions in Benue State will provide evidence on whether and how these technologies contribute to improved instructional practices. Such evidence could inform educational policy, lecturer professional development, curriculum implementation, and institutional investment in appropriate technologies for improving Geometry teaching and learning.

1.1 Statement of the Problem

In the face of the growing adoption of Artificial Intelligence (AI) tools in education, there is limited empirical evidence on their specific effect on the teaching effectiveness of Geometry in tertiary mathematics. Geometry requires strong spatial reasoning, visualization, and conceptual understanding, and although AI tools offer opportunities for interactive visualization, personalized learning, and immediate feedback, it remains unclear whether these benefits translate into improved instructional quality and learning outcomes (Holmes et al., 2021; Lo et al., 2024).

Effective integration of AI may also be constrained by lecturers' limited training, confidence, technological competence, inadequate infrastructure, insufficient institutional support, and unclear policy guidance (Ayanwale et al., 2024). In Benue State, these challenges may contribute to the underutilization or inconsistent application of AI tools in Geometry instruction. However, there is insufficient systematic evidence on how lecturers use AI, the extent of its integration, and its influence on instructional delivery, student engagement, visualization, assessment, and learning outcomes. Consequently, educators, institutional administrators, and policymakers lack adequate evidence to determine whether AI tools meaningfully enhance Geometry teaching or address existing instructional challenges. This gap underscores the need to investigate the effect of AI tool usage on the teaching effectiveness of Geometry in tertiary institutions in Benue State. The study provides empirical evidence on the extent and patterns of AI integration, its contribution to instructional effectiveness, and the challenges that may influence its successful adoption.

1.2 Objectives of the Study

The main objective of this study is to examine the effect of Artificial Intelligence (AI) tools on teaching effectiveness of geometry in tertiary institutions in Benue State. The specific objectives are to:

1. Determine the extent to which AI tools are used by lecturers in teaching geometry in tertiary institutions in Benue State.
2. Examine the influence of AI tools on effective teaching of geometric concepts.
3. Assess the effect of AI tools on student engagement during geometry lessons.
4. Evaluate the impact of AI tools on assessment and feedback practices in geometry instruction.
5. Identify challenges associated with integrating AI tools in geometry teaching.

1.3 Research Questions

This study is guided by the following research questions:

1. To what extent are AI tools used in teaching geometry in tertiary institutions in Benue State?
2. How do AI tools influence effective teaching of geometry concepts?
3. What effect do AI tools have on student engagement in geometry lessons?

4. How do AI tools impact assessment and feedback practices in geometry instruction?
5. What challenges do lecturers face in integrating AI tools in geometry teaching?

1.4 Research Hypotheses

The following null hypotheses were formulated and tested at the 0.05 level of significance:

H₀₁: AI tools do not have significant influence on effective teaching of geometry concepts.

H₀₂: AI tools do not significantly influence student engagement in geometry lessons.

H₀₃: AI tools do not have significantly impact on the assessment and feedback practices in geometry instruction

2.2 Conceptual Review

2.1.1 Artificial Intelligence (AI)

Artificial Intelligence refers to computational systems capable of performing tasks that would ordinarily require human intelligence, including reasoning, pattern recognition, language understanding, and problem-solving (Awang et al., 2025). Simply put, Haruna, Alhassan, Yakubu, Ahmad and Gurjiya (2025) described Artificial intelligence (AI) as the theory and development of computer systems capable of performing tasks that historically required human intelligence, such as recognizing speech, making decisions, and identifying patterns. Artificial intelligence (AI) is a multidisciplinary field that focuses on developing intelligent machines that can perform tasks typically performed by humans (Mohamed et al., 2022). In educational contexts, AI technologies are designed to support teaching and learning processes by offering adaptive feedback, automated assessments, intelligent tutoring, predictive analytics, and personalized learning pathways (Opesemowo & Ndlovu, 2024). Examples include intelligent tutoring systems (ITS), chatbots, virtual assistants, and dynamic visualization environments.

2.1.2 AI Tools in Education

AI tools in education encompass software and platforms that leverage machine learning, natural language processing, and data mining to enhance instructional practices. These tools may be grouped into categories such as:

- **Instructional Delivery Tools:** Intelligent tutoring systems and virtual facilitators that tailor instruction to learner needs (Walter, 2024; Holmes et al., 2022).
- **Assessment and Feedback Tools:** Automated grading systems and analytics dashboards that provide immediate feedback (Baker & Inventado, 2014).
- **Dynamic Visualization Tools:** Systems that allow interactive exploration of mathematical concepts (Mohamed et al., 2022).
- **Adaptive Learning Platforms:** Tools that personalise content sequencing based on learner performance (Opesemowo & Ndlovu, 2024).

AI-supported mathematics instruction can address the limitations of standardized teaching by providing individualized learning pathways, adaptive instructional materials, and real-time feedback tailored to learners' needs. AI-generated resources including worked examples, practice tasks, visualisations, formative assessments, hints, and adaptive sequences can strengthen learning and achievement while helping educators respond to curriculum gaps (Awang et al., 2025; Opesemowo & Adewuyi, 2024; Kosoko-Oyedeko et al., 2025; Ogoke et al., 2025). However, these benefits depend on effective pedagogical integration; AI should enhance rather than replace teachers' professional judgement and meaningful learner engagement (Walter, 2024; Walter, 2024).

2.1.3 Teaching Effectiveness

Teaching effectiveness involves the ability of an instructor to facilitate meaningful learning, foster engagement, promote critical thinking, and enhance students' academic outcomes (McGalliard & Otten, 2025). Effective teaching in geometry requires clear explanations of abstract concepts, use of pedagogical strategies that support spatial reasoning, and provision of timely, actionable feedback. Teaching effectiveness encompasses:

- Clarity of instruction
- Student engagement and participation
- Feedback quality
- Achievement of learning outcomes

AI tools are posited to influence these indicators by enhancing visualization, automating routine tasks, and supporting continuous student monitoring.

2.1.4 Geometry and Mathematics Education

Geometry is an aspect of mathematics that deals with the study of different shapes. These shapes may be plane or solid. A plane shape is a geometrical form such that the straight line that joins any two points on it wholly lies on the surface (Akintade, Ogunrinade & Awe, 2024). Unlike procedural topics such as arithmetic, geometry poses unique cognitive demands, requiring learners to visualize spatial structures, understand transformations, and construct logical proofs (McGalliard & Otten, 2025). These demands make effective instruction more complex, often requiring multiple representations and interactive exploration.

2.2 Theoretical Framework

2.2.1 Constructivist Theory

Constructivism posits that learners construct knowledge actively through engagement and interaction with their environment (Piaget, 1952). This theory underpins the use of AI tools in instruction, as these technologies allow learners to engage actively with content. For example, interactive geometry software encourages learners to manipulate figures, test hypotheses, and receive immediate feedback, thereby facilitating knowledge construction rather than passive absorption.

2.2.2 Cognitive Load Theory

Cognitive Load Theory (CLT) suggests that learning occurs most effectively when instructional design minimizes extraneous cognitive load, allowing working memory to focus on schema acquisition (Sweller, 1988). Geometry's abstract nature places high intrinsic cognitive demands on learners. AI tools that dynamically visualize geometric concepts reduce extraneous load by presenting information in intuitive formats, allowing learners to allocate cognitive resources more efficiently toward deeper understanding.

2.2.3 Technology Acceptance Model (TAM)

The Technology Acceptance Model explains how users come to accept and use technology. TAM posits that perceived usefulness and ease of use influence attitudes toward, and actual use of, technology (Davis, 1989). This framework helps explain lecturers' adoption decisions concerning AI tools — if lecturers find AI tools useful and easy to use, they are more likely to integrate them into teaching geometry.

2.3 AI Tools and Teaching Mathematics

2.3.1 Global Perspectives on AI in Mathematics Education

Globally, the integration of AI into mathematics education is increasingly recognized for its capacity to personalize learning, provide immediate feedback, automate assessment, and support teachers' professional development. AI-powered applications such as Photomath, Mathway, Maple Calculator, and Microsoft Math Solver can help learners identify errors and strengthen problem-solving skills, while intelligent tutoring systems adapt instruction to individual learning needs (Holmes et al., 2021; Awang et al., 2025; Ayanwale et al., 2024). However, these benefits should not be interpreted uncritically, as excessive reliance on automated solutions may weaken learners' independent reasoning and reduce the pedagogical role of teachers. Thus, the global evidence suggests that AI is most effective when used as a complement to, rather than a replacement for, sound mathematical pedagogy and teacher guidance (Akintade & Olaore, 2025; Opesemowo & Ndlovu, 2024).

2.3.2 AI Tools Specific to Geometry

AI tools designed for geometry instruction include software such as Geogebra enhanced with AI feedback modules, computer vision-based proof assistants, and adaptive problem-solvers that guide students' step-by-step through geometric constructions. These tools support the visualization of multidimensional shapes and relationships, allow experiential learning through manipulation of geometric objects, and provide just-in-time guidance that helps students avoid misconceptions (Opesemowo & Ndlovu, 2024). As Awang et al. (2025) pointed out dynamic geometry environments that incorporate AI allow students to visualize complex structures, explore transformations, and test hypotheses, which is particularly valuable for spatially demanding topics.

2.4 Empirical Studies

Artificial Intelligence (AI) has emerged as a promising tool for addressing challenges in mathematics education and advancing pedagogical innovation. Its growing adoption reflects global efforts to leverage technology to improve teaching and learning outcomes. Studies conducted in technologically advanced educational environments have shown that AI can enhance student engagement, strengthen problem-solving skills, provide timely feedback, and increase learner motivation (Awang et al., 2025; Mohamed et al., 2022; Opesemowo & Ndlovu, 2024; Holmes et al., 2021; Opesemowo & Ndlovu, 2024). However, these positive outcomes are largely documented in contexts with strong technological infrastructure and high levels of digital readiness, which may not reflect the realities of many tertiary institutions in Benue State.

The effectiveness of AI integration is influenced by critical factors such as lecturers' technological competence, institutional support, internet accessibility, and curriculum alignment with AI-enabled learning opportunities (Walter, 2024). Where these conditions are lacking, AI implementation may be limited and less impactful. Given the resource constraints and instructional challenges facing tertiary institutions in Benue State, there is a need to examine the extent to which AI tools are adopted in geometry instruction and their contribution to teaching effectiveness. Such evidence is essential for informing educational policies, strengthening professional development programmes, and guiding investments that support meaningful AI integration in teaching and learning.

3.0 Methodology

This research was carried out in Benue State, Nigeria in the state-owned tertiary institutions in all the three educational zones (A, B, and C) of the state. The study makes use of cross-sectional survey design with correlational analysis method to carry out investigation into the effect of the usage of Artificial Intelligence tools on the teaching effectiveness in the instruction of geometry in the colleges. Approximately 120 mathematics lecturers and 3,500 undergraduate students in the various colleges teaching geometry constituted the target population. The sample size of 60 lecturers of geometry and 175 students in the colleges of education, were obtained using stratified, purposive and random sampling methods making the total 235 sample sizes. The data was gathered via the administration of a structured questionnaire christened; Effect of Artificial Intelligence Tools on Teaching Effectiveness of Geometry in Tertiary Institutions Questionnaire (EAITTEGTIQ).

Face validity and pilot testing with selected lecturers and students from unselected Institutions were used to guarantee instrument's validity. Cronbach's Alpha coefficients was used to obtain reliability. The study analyzes quantitative data through descriptive statistics and multiple regressions using SPSS package version 27.

Model for Hypothesis One: AI and Effective Teaching

$$ETGC_i = \beta_0 + \beta_1 AI_i + \beta_2 GEN_i + \beta_3 AGE_i + \beta_4 QUAL_i + \beta_5 TE_i + \beta_6 INST_i + \mu_i \dots\dots\dots (1)$$

Where:

ETGC_i = Effective Teaching of Geometry Concepts

AI_i = AI Tool Usage Index

GEN_i = Gender

AGE_i = Age

QUAL_i = Educational Qualification

TE_i = Teaching Experience

INST_i = Institution Type

β_0 = Constant/intercept

$\beta_1 - \beta_6$ = Regression coefficients

μ_i = Error term

Decision criterion: The hypothesis is rejected if the coefficient of AI (β_1) is statistically significant at $p < 0.05$.

Model for Hypothesis Two: AI and Student Engagement

$$SE_i = \beta_0 + \beta_1 AI_i + \beta_2 GEN_i + \beta_3 AGE_i + \beta_4 QUAL_i + \beta_5 TE_i + \beta_6 INST_i + \mu_i \dots\dots\dots (2)$$

Where SE_i = Student Engagement in Geometry

The key coefficient is β_1 . A statistically significant positive β_1 at the 5% level indicates that AI usage significantly influences student engagement.

Model for Hypothesis Three: AI and Assessment/Feedback

$$AF_i = \beta_0 + \beta_1 AI_i + \beta_2 GEN_i + \beta_3 AGE_i + \beta_4 QUAL_i + \beta_5 TE_i + \beta_6 INST_i + \mu_i \dots\dots\dots (3)$$

Where AF_i = Assessment and Feedback Practices

Again, β_1 is the principal coefficient of interest. If $p < 0.05$, the null hypothesis is rejected.

4.0 Results and Discussions

To what extent are AI tools used in teaching geometry in tertiary institutions in Benue State?

The results are as in Table 1.

Table 1: Mean Ratings on AI Tool Usage

S/N	Item	Mean	SD	Decision
1	I use AI-powered tools when teaching geometry	3.24	0.76	Agreed
2	I use AI tools for generating instructional materials	3.11	0.82	Agreed
3	I use dynamic geometry software for visualization	3.32	0.71	Agreed
4	AI tools help design geometry exercises	3.09	0.87	Agreed
5	AI tools provide automated feedback	2.96	0.88	Agreed
6	AI tools assist in assessment of assignments	2.85	0.93	Agreed
7	AI tools monitor learning progress	2.78	0.91	Agreed
8	AI tools reduce grading time	3.18	0.74	Agreed
9	AI tools are integrated during instruction	3.01	0.83	Agreed
10	Students are encouraged to use AI tools	3.27	0.72	Agreed
	Grand Mean	3.08	0.82	Agreed

Source: Computed by Researcher, 2026

From Table 1, the grand mean score of 3.08 was higher than the criterion mean of 2.50, thereby portraying a moderate to high extent of use of AI tools in geometry teaching in tertiary institutions of Benue State. Visualization as provided by dynamic geometry software was the highest rated item with a Mean of 3.32 indicating that AI tools had mostly contributed to the visual aspect of geometry instruction.

How do AI tools influence effective teaching of geometry concepts?

The influence of AI tools on effective teaching of geometry concepts is as presented in Table 2.

Table 2: Influence of AI Tools on Effective Teaching

S/N	Item	Mean	SD	Decision
1	AI tools improve clarity in explaining concepts	3.41	0.68	Agree
2	AI tools enhance visualization of figures	3.58	0.61	Agree
3	AI tools simplify abstract topics	3.46	0.72	Agree
4	AI improves instructional strategies	3.29	0.75	Agree
5	AI helps address misconceptions	3.18	0.79	Agree
6	Grand Mean	3.38	0.71	Agreed

Source: Computed by Researcher, 2026

The grand mean of 3.38 in Table 2 indicates that AI tools positively influence instructional delivery of geometry. Respondents strongly agreed that AI enhances visualization of geometric figures (Mean = 3.58), which is essential in teaching abstract geometric concepts.

What effect do AI tools have on student engagement in geometry lessons?

The effect of AI tools on student engagement has been presented in Table 3.

Table 3: Effect of AI Tools on Student Engagement

S/N	Item	Mean	SD	Decision
1	AI tools increase participation	3.30	0.74	Agree
2	AI tools motivate students	3.36	0.69	Agree
3	AI tools stimulate interest in geometry	3.42	0.67	Agree
4	AI tools encourage collaborative learning	3.21	0.83	Agree

5	AI tools promote independent learning	3.47	0.71	Agree
6	Grand Mean	3.35	0.73	Agree

Source: Computed by Researcher, 2026

The findings in Table 3 reveals that AI tools positively affect student engagement in geometry lessons. The highest mean score was obtained for promotion of independent learning (Mean = 3.47), suggesting that AI tools facilitate self-paced learning.

How do AI tools impact assessment and feedback practices in geometry instruction?

The impact of AI tools on assessment and feedback is as reflected in Table 4.

Table 4: Impact of AI Tools on Assessment and Feedback

S/N	Item	Mean	SD	Decision
1	AI tools provide timely feedback	3.44	0.66	Agreed
2	AI assessment improves grading accuracy	3.26	0.79	Agreed
3	AI identifies students' weaknesses	3.38	0.72	Agreed
4	AI improves students' performance	3.31	0.74	Agreed
5	AI-supported feedback enhances understanding	3.49	0.64	Agreed
6	Grand Mean	3.38	0.71	Agreed

Source: Computed by Researcher, 2026

The results of the grand mean of 3.38 in Table 4 indicates that AI tools positively impact assessment and feedback practices. Respondents particularly agreed that AI-supported feedback enhances understanding of geometric proofs and concepts.

What challenges do lecturers face in integrating AI tools into geometry teaching?

The challenges of AI integration have been presented in Table 4.

Table 5: Challenges of AI Integration

S/N	Item	Mean	SD	Decision
1	Lack of infrastructure limits AI use	3.56	0.65	Agreed
2	Lack of training affects AI integration	3.47	0.70	Agreed
3	Students misuse AI tools	3.19	0.83	Agreed
4	AI reduces teacher-student interaction	2.88	0.91	Agreed
5	Institutional policies are unclear	3.35	0.77	Agreed
6	Grand Mean	3.29	0.77	Agreed

Source: Computed by Researcher, 2026

The results from Table 5 show that the respondents agreed that significant challenges hinder effective AI integration. The most serious challenge identified was inadequate infrastructure (Mean = 3.56), followed by insufficient lecturer training (Mean = 3.47).

Test of Hypotheses

Hypothesis One

H₀₁: AI tools do not have significant influence on effective teaching of geometry concepts.

Table 6: Multiple Regression Analysis of AI Tool Usage and Effective Teaching of Geometry Concepts

Predictor	B	Std. Error	Beta (β)	t	Sig.
Constant	1.214	0.284	—	4.275	.000
AI Tool Usage	0.527	0.083	0.612	6.349	.000
Gender	0.061	0.049	0.084	1.245	.218

Age	0.038	0.031	0.071	1.226	.225
Qualification	0.074	0.035	0.121	2.114	.039
Teaching Experience	0.056	0.027	0.118	2.074	.043
Institution Type	0.069	0.033	0.126	2.091	.041

Source: Computed by Researcher, 2026

Model Summary: $R = 0.671$; $R^2 = 0.450$; Adjusted $R^2 = 0.388$; $F(5,54) = 8.84$; $p < .001$

Table 6 shows that AI tool usage significantly and positively predicts effective teaching of geometry concepts ($B = 0.527$, $\beta = 0.612$, $t = 6.349$, $p < .001$), explaining 45.0% of the variance in teaching effectiveness ($R^2 = 0.450$). Thus, the null hypothesis was rejected, indicating that purposeful AI use is associated with improved geometry instruction. This finding agrees with the descriptive result ($M = 3.38$), particularly the high rating for AI-enhanced visualization ($M = 3.58$), suggesting that visualization is a key pathway through which AI supports effective geometry teaching.

Hypothesis Two

H_{02} : AI tools do not significantly influence student engagement in geometry lessons.

Table 7: Regression Analysis of AI Tool Usage and Student Engagement

Predictor	B	Std. Error	Beta (β)	t	Sig.
Constant	1.086	0.301	—	3.608	.001
AI Tool Usage	0.581	0.091	0.641	6.385	.000
Gender	0.048	0.052	0.059	0.923	.360
Age	0.029	0.034	0.047	0.853	.398
Qualification	0.067	0.038	0.089	1.763	.083
Teaching Experience	0.041	0.029	0.075	1.414	.163

Source: Computed by Researcher, 2026

Model Summary: $R = 0.654$; $R^2 = 0.428$; Adjusted $R^2 = 0.386$; $F(4,55) = 10.29$; $p < .001$

Table 7 indicates that AI tool usage significantly and positively predicts student engagement in geometry lessons ($B = 0.581$, $\beta = 0.641$, $t = 6.385$, $p < .001$), with the model explaining 42.8% of the variation in engagement ($R^2 = 0.428$). The null hypothesis was therefore rejected. This finding is consistent with the descriptive result ($M = 3.35$), particularly the ratings for independent learning ($M = 3.47$) and stimulation of interest in geometry ($M = 3.42$), suggesting that AI may enhance engagement by supporting self-paced exploration, practice, interaction, and immediate assistance. However, given the cross-sectional design, the result indicates association rather than causation.

Hypothesis Three

H_{03} : AI tools do not have significant impact on assessment and feedback practices in geometry instruction.

Table 8: Regression Analysis of AI Tool Usage and Assessment and Feedback Practices

Predictor	B	Std. Error	Beta (β)	t	Sig.
Constant	1.172	0.296	—	3.959	.000
AI Tool Usage	0.548	0.086	0.628	6.372	.000
Gender	0.054	0.050	0.071	1.080	.285
Age	0.031	0.033	0.052	0.939	.352
Qualification	0.079	0.037	0.113	2.135	.037

Teaching Experience	0.047	0.028	0.098	1.679	.099
---------------------	-------	-------	-------	-------	------

Source: Computed by Researcher, 2026

Model Summary: $R = 0.649$; $R^2 = 0.421$; Adjusted $R^2 = 0.379$; $F(4,55) = 9.98$; $p < .001$

Table 8 indicates that AI tool usage significantly and positively predicts assessment and feedback practices in geometry instruction ($B = 0.548$, $\beta = 0.628$, $t = 6.372$, $p < .001$), with the model explaining 42.1% of the variance ($R^2 = 0.421$). The null hypothesis was therefore rejected. This result is consistent with the descriptive finding ($M = 3.38$), particularly AI-supported feedback enhancing understanding ($M = 3.49$) and timely feedback ($M = 3.44$), suggesting that AI can facilitate faster, more targeted feedback and assessment. However, professional judgement remains essential, as automated feedback may contain errors or inadequately address complex mathematical reasoning.

4.2 Discussion of Findings

The study found that AI tools were used to a moderate-to-high extent in teaching geometry (Grand Mean = 3.08), with dynamic visualization receiving the highest rating ($M = 3.32$). This suggests that lecturers particularly value AI for making abstract geometric concepts more visible and understandable. The finding agrees with Opesemowo and Adewuyi (2024), whose systematic review identified enhanced mathematics instruction, personalized learning, and technology-supported instructional processes as major benefits of AI in mathematics education.

AI tool usage also significantly predicted effective teaching of geometry ($\beta = .612$, $p < .001$), explaining 45.0% of the variation in teaching effectiveness. This finding supports Opesemowo and Adewuyi (2024), who reported that AI can strengthen mathematics instruction through personalized support and enhanced instructional processes. It is also consistent with Colliot et al. (2024), whose geometry study demonstrated that AI-supported adaptive feedback improved learners' performance and transfer, suggesting that the pedagogical features of AI, rather than technology alone, are important for effective mathematics learning.

The finding that AI significantly predicted student engagement ($\beta = .641$, $p < .001$) is consistent with the position that interactive and responsive AI applications can stimulate learners' participation, interest and independent learning. However, the finding should be interpreted cautiously. Lo, Hew and Jong (2024), after reviewing 72 empirical studies, reported both engagement and disengagement in AI-supported learning. They found evidence of increased behavioural engagement but also concerns about overreliance, reduced critical thinking and academic dishonesty. Thus, the positive engagement result in the present study does not imply that AI automatically produces meaningful engagement; rather, its effectiveness depends on how lecturers structure its use. AI also significantly predicted assessment and feedback practices ($\beta = .628$, $p < .001$), accounting for 42.1% of the variance. This finding strongly agrees with Colliot et al. (2024), who found that real-time AI-based adaptive feedback significantly improved geometry learning and transfer. It also supports Opesemowo and Adewuyi (2024), who identified real-time assessment and feedback as important applications of AI in mathematics education.

Finally, infrastructure deficiency ($M = 3.56$), inadequate training ($M = 3.47$) and unclear institutional policies ($M = 3.35$) emerged as major challenges. This indicates that technological availability alone is insufficient for successful AI integration. The findings therefore reinforce the broader literature that effective AI-supported mathematics education requires lecturer competence, institutional support, appropriate infrastructure and clear pedagogical guidelines. Overall, the

study supports AI as a complement to lecturers rather than a replacement for them, with its educational value depending largely on purposeful and professionally guided implementation.

5.1 Conclusion

The study concludes that Artificial Intelligence (AI) tools significantly enhance teaching effectiveness of geometry in tertiary institutions in Benue State. AI usage significantly predicted effective teaching, student engagement, and assessment and feedback practices, indicating that AI-supported visualization, instructional materials, interactive learning and timely feedback can improve the teaching and learning of geometric concepts. However, the findings also show that the benefits of AI integration are constrained by inadequate infrastructure, limited lecturer training and unclear institutional policies. Thus, AI should be viewed as a complementary pedagogical resource that strengthens, rather than replaces, the professional role of mathematics lecturers.

5.2 Recommendations

Based on the findings, the study recommends that tertiary institutions should:

1. Improve ICT infrastructure by providing reliable electricity, internet connectivity, computers and appropriate AI-enabled geometry applications.
2. Provide continuous professional development to equip mathematics lecturers with the technical, pedagogical and ethical competencies required for effective AI integration.
3. Promote AI-supported visualization and feedback in geometry instruction to simplify abstract concepts, improve students' understanding and provide timely formative feedback.
4. Develop clear institutional AI policies addressing responsible use, academic integrity, data privacy and students' appropriate reliance on AI-generated content.
5. Integrate AI with conventional teaching approaches so that lecturers retain professional judgement while using AI to support explanation, assessment, problem-solving and student engagement.
6. Strengthen students' AI literacy to encourage responsible use of AI as a learning support tool while maintaining independent mathematical reasoning and problem-solving skills.

Funding: This paper is sponsored by the Tertiary Education Trust Fund (TETFUND), intervening in many fields of academic endeavor, pushing research forward through Institutional Base Research (IBR) and National Research Fund (NRF).

References

- Akintade, C. A., Ogunrinade, S. O., & Awe, I. A. (2024). Effectiveness of geometrical instructional teaching strategy on junior secondary school students' achievement, gender and attitude in plane geometry in Odeda Local Government, Ogun State, Nigeria. *International Journal of Science and Research Archive*, 11(2), 1306–1315. <https://doi.org/10.30574/ijrsra.2024.11.2.0485>
- Akintade, C. A., & Olaore, F. A. (2025). Effect of integrating artificial intelligence (AI) on the teaching and learning of geometry within secondary schools in Ogun Central Senatorial Districts, Nigeria. *International Journal of Research and Innovation in Social Science*, 9(9), 198–209. <https://doi.org/10.47772/IJRISS.2025.909000018>
- Ayanwale, M. A., Adelana, O. P., Molefi, R. R., Adeeko, O., & Ishola, A. M. (2024). Examining artificial intelligence literacy among pre-service teachers for future classrooms. *Computers and Education Open*, 6, Article 100179. <https://doi.org/10.1016/j.caeo.2024.100179>
- Awang, L. A., Yusop, F. D., & Danaee, M. (2025). Current practices and future direction of artificial intelligence in mathematics education: A systematic review. *International Electronic Journal of Mathematics Education*, 20(2), Article em0823.
- Baker, R. S., & Inventado, P. S. (2014). Educational data mining and learning analytics. In J. A. Larusson & B. White (Eds.), *Learning analytics: From research to practice* (pp. 61–75). Springer. https://doi.org/10.1007/978-1-4614-3305-7_4
- Colliot, T., Krichen, O., Girard, N., Anquetil, É., & Jamet, É. (2024). What makes tablet-based learning effective? A study of the role of real-time adaptive feedback. *British Journal of Educational Technology*, 55(5), 2278–2295. <https://doi.org/10.1111/bjet.13439>
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340. <https://doi.org/10.2307/249008>
- Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Buckingham Shum, S., Santos, O. C., Rodrigo, M. T., Cukurova, M., Bittencourt, I. I., & Koedinger, K. R. (2022). Ethics of AI in education: Towards a community-wide framework. *International Journal of Artificial Intelligence in Education*, 32(3), 504–526. <https://doi.org/10.1007/s40593-021-00239-1>
- Lo, C. K., Hew, K. F., & Jong, M. S.-Y. (2024). The influence of ChatGPT on student engagement: A systematic review and future research agenda. *Computers & Education*, 219, Article 105100. <https://doi.org/10.1016/j.compedu.2024.105100>
- Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence unleashed: An argument for AI in education*. Pearson.
- McGalliard, W., & Otten, S. (2025). AI responses to challenging problems and educator responses to AI availability. *Digital Experiences in Mathematics Education*, 11(1), 319–332. <https://doi.org/10.1007/s40751-024-00167-4>
- Mohamed, M. Z. B., Hidayat, R., Suhaizi, N. N. B., Sabri, N. B. M., Mahmud, M. K. H. B., & Baharuddin, S. N. B. (2022). Artificial intelligence in mathematics education: A systematic literature review. *International Electronic Journal of Mathematics Education*, 17(3), Article em0694. <https://doi.org/10.29333/iejme/12132>
- Ogoke, C. J., Anyanwu, A., Okolie, A., Onuoha, E., & Vivian, D.-O. (2025). Application of artificial intelligence in the teaching and learning of mathematics: Implication for achievement and retention. *Eureka: Journal of Educational Research*, 3(2), 136–143. <https://doi.org/10.56773/ejer.v3i2.62>

- Opesemowo, O. A. G., & Adewuyi, H. O. (2024a). A systematic review of artificial intelligence in mathematics education: The emergence of 4IR. *Eurasia Journal of Mathematics, Science and Technology Education*, 20(7), Article em2478. <https://doi.org/10.29333/ejmste/14762>
- Opesemowo, O. A. G., & Ndlovu, M. (2024b). Artificial intelligence in mathematics education: The good, the bad, and the ugly. *Journal of Pedagogical Research*, 8(3), 333–346. <https://doi.org/10.33902/JPR.202426428>.
- Piaget, J. (1952). The origins of intelligence in children (M. Cook, Trans.). International Universities Press.
- Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, 12(2), 257–285. https://doi.org/10.1207/s15516709cog1202_4
- Walter, Y. (2024). Embracing the future of Artificial Intelligence in the classroom: The relevance of AI literacy, prompt engineering, and critical thinking in modern education. *International Journal of Educational Technology in Higher Education*, 21, Article 15. <https://doi.org/10.1186/s41239-024-00448-3>.
- Yue, M., Jong, M. S.-Y., & Ng, D. T. K. (2024). Understanding K–12 teachers' technological pedagogical content knowledge readiness and attitudes toward artificial intelligence education. *Education and Information Technologies*, 29(1), 19505–19536. <https://doi.org/10.1007/s10639-024-12621-2>.
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education—Where are the educators? *International Journal of Educational Technology in Higher Education*, 16, Article 39. <https://doi.org/10.1186/s41239-019-0171-0>