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Effectiveness of AI-Designed Instructional Materials on Mathematics Achievement of Secondary School Students in Lagos State

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Abstract

Mathematics achievement serves as a crucial foundation for success in the fourth industrial revolution and for addressing real-life problems. Leveraging artificial intelligence (AI) in instructional design offers promising opportunities to enhance mathematics teaching and learning in secondary schools. This study investigated the effectiveness of AI-designed instructional materials on the mathematics achievement of secondary school students in Lagos State, Nigeria. The study was guided by two research questions and two hypotheses. The population comprised all secondary school students in Lagos State, while the sample included 312 students randomly selected from seven schools. Data were collected using the AI-Designed Instructional Materials for Mathematics Achievement Scale (AIMMAS), which consisted of three sections: demographic data, AI-designed instructional materials, and students' previous annual mathematics scores. The instrument demonstrated good reliability (Cronbach's alpha = 0.87) and acceptable face and content validity. Data were analyzed using descriptive statistics (percentages, means, and standard deviations) and inferential statistics (ANOVA and t-test) at a 0.05 significance level. Results showed that AI-designed instructional materials had a significant positive effect on students' mathematics achievement compared to traditional methods, leading to the rejection of the first null hypothesis. Conversely, gender had no significant influence on mathematics achievement, and the second null hypothesis was not rejected. The findings suggest that integrating AI-designed instructional materials enhances mathematics performance, irrespective of gender. It is recommended that school authorities promote and adequately fund the use of AI-driven instructional resources, while teachers and students actively adopt these materials to strengthen mathematics teaching and learning.

Keywords: *AI-Designed Instructional Materials, Mathematics Achievement, Secondary Schools, Students*

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Background to the Study

As technology advances, education continues to evolve and change in many ways. Therefore, the traditional method of teaching students in the classroom is outdated. In the quest for education for all, and the place of technology, mathematics education plays a very significant role. Mathematics is the foundation of all technological developments and economic survival (Ogoke et al., 2025). Mathematics education is crucial for developing critical thinking, problem solving, and analytical skills that are essential for growth. Challenges in mathematics education, particularly in Nigeria, require innovative approaches to improve its learning outcomes (Kannadass et al., 2023). Despite, these huge benefits of mathematics, it has been discovered that most students do not like the subject, given rise to reduced performance or achievement in mathematics.

Mathematics achievement can be described as how well and accurate a student demonstrates the mastery of what he/she has been taught in mathematics in term of expertise, understanding and skills as reflected in their performance. It encompasses procedural fluency, conceptual understanding, reasoning, and the ability to apply mathematical knowledge to real-life situations (Kuhfeld et al., 2025). Put succinctly, mathematics achievement is the competency shown by the student in mathematics. It is the result of acquired knowledge, information, and techniques developed in the subject of mathematics at a particular stage. Mathematics achievement measure is the score on the achievement test in mathematics. It is an essential part of the academic achievement in the modern era, and the key to success in many professions (Pandey, 2017). In addition, Breit et al. (2024) stated that mathematics achievement is the mathematics-related performance outcomes that indicate the extent to which a person has accomplished specific goals that were the focus of activities, specifically in schools.

According to OECD (2018), high mathematics achievement is a central goal of school instruction and a foundation for success in many professions, for solving everyday problems, and for participating in society as a constructive and reflective citizen. Mathematical achievement improves chances in the job market, financial well-being, risk assessment and decision-making. A central source of mathematical competence is the school instruction and right application of relevant instructional materials. Studies by Dowker (2019) and Dowker et al., (2019), showed that students sharing the same teacher and class can differ strongly in mathematics achievement due to several factors such as school environment, teacher's qualification, available materials, and adoption of technology such as AI-driven tools. These individual differences in mathematics achievement among students are usually frequent and large. A better understanding of the sources of individual differences in mathematics can be used to create instruction that adapts to learners' individual characteristics and needs such as Intelligent Tutoring Systems, identify students at risk for mathematical learning difficulties and mathematically gifted students who would profit from specialized instruction, enhance approaches for closing achievement gaps between students (Breit, et al. 2024).

As Ogoke and Okigbo (2021) emphasised, teachers must establish a strong foundation for instruction through effective planning and implementation processes. This foundation is

essential mathematics learning. Rapid technological advancements and changing workforce needs have widened the skill gap, affecting student performance and future prospects. According to Mawak and Odulum (2024), the need for improved achievement in Mathematics has driven teachers and researchers to seek appropriate instructional and assessment strategies, by providing students with the opportunity to use the feedback to improve learning as well allow students to develop the required attitude towards the subject. Therefore, one of the technological tools that can enhance students' achievements in mathematics is AI-designed instructional materials.

AI-Designed Instructional Materials

Today, educators are leveraging Artificial intelligence technologies to fill identified gaps within the curriculum and tailor instructional methodologies to better meet students' specific needs (Rasheed et.al, 2023; Opesemowo & Adewuyi, 2024). AI-designed instructional materials for mathematics are various learning resources such as lessons, charts, worked examples, hints, practice sets, formative assessments, visualisations, feedback scripts, sequencing/adaptive pathways, or tutor agents that are created, adapted, or delivered by AI methods, and can significantly improve students learning and achievement in mathematics. (Ogoke et al., 2025). Incorporating AI into the design of educational instructional materials can provide learning support, curriculum adaptation (Walter, 2024); enabling scalable learning and provide real-time feedback (Onesi-Ozigagun et al. 2024). With it, educators can create inclusive environments that empower students for the digital age.

Research by George and Jaleel (2025), revealed that students who use AI-enhanced learning tools tend to perform better academically, particularly in subjects like mathematics and science, where adaptive learning systems are frequently applied, but a lot of them are not favourably disposed to its usage. For example, AI-platforms like DreamBox Learning have shown significant improvements in mathematics proficiency among students. However, AI integration presents challenges such a data privacy, algorithmic bias, and teacher training. Issues around inclusion, equity, and access must be addressed for the benefit all students (Tang 2024).

Role of Artificial Intelligence (AI) in Mathematics Education

In recent years, the emergence of artificial intelligence (AI) has been recognized as a transformative force in the field of mathematics education. AI-powered instructional materials markedly enrich digital learning environments by systematically analysing student behaviour, delivering real-time feedback, and customizing instruction to meet the distinct learning needs of individual students (Tang, 2025). These technologies improve students' mathematics skills by enhancing their comprehension, boosts engagement, support critical thinking and enhance performance (Walter, 2024). A study by Fawehinmi et al. (2025), showed that AI integration enhances mathematics performance compared to traditional methods. Also, a study by Opesemowo and Adewuyi (2024), revealed that various AI tool such as ChatGPT provides personalised support, facilitate real-time assessments, and generate interactive explanations. These innovative tools in mathematics appears to reduce student failure and increase success rates (Alkhasawneh, 2025). In specific terms, AI-designed instructional materials perform the following functions:

1. **Personalised Learning Platforms:** AI-driven personalised instructional materials platforms can analyse students' learning behaviours, preferences, performance, and create activities that are tailored to individual interests and learning styles (Rasheed et al., 2023). Studies have indicated that AI-based tools can impact on student achievement in mathematics positively (Yi et al., 2023).

2. **Automated Assessment and Feedback:** AI Platforms such as ASSISTMENTS and ALEKS can provide immediate, automated feedback, with studies illustrating that real-time feedback can substantially enhance and improve student learning outcomes ((Ogoke et al., 2025)).

3. **Gamification Elements:** With games, AI tools can motivate students to tackle complex mathematical problems with increased enthusiasm, create engaging learning environments, and enhance critical thinking skills, making mathematics more exciting for students (Walter, 2024).

4. **Intelligent Tutoring Systems (ITS):** Stepwise problem solvers that provide hints, diagnose errors, and model student knowledge.

5. **Generative-AI materials**: Automatically created worked examples, alternative explanations, problem variants, and visualizations using large language / image models

6. **AI-assisted Curriculum Design:** AI systems can illuminate specific topics that necessitate greater focus, modifications, or integration of alternative instructional strategies. (Yi et al., 2023).

Examples of AI-Designed Instructional Materials for Mathematics

1. **Generative AI (ChatGPT-based):** This AI-designed instructional material allows students to interact with AI systems to solve mathematics problems, receive personalised explanations, and practice key concepts, while teachers supervised the process (World Bank, 2024).
2. **uLesson:** This is a tool that integrates video lessons, quizzes, and an AI-powered "Ask" feature that allows learners to upload images or text of mathematics problems and receive step-by-step worked solutions (uLesson, 2024).
3. **Darsel**: It delivers mathematics tutoring through SMS and WhatsApp chatbots, providing learners with automated step-by-step solutions, even on low-bandwidth devices. This is especially relevant in rural where reliable internet or advanced smartphones are scarce (Darsel, 2023).
4. **Rori**: This tool operates as a WhatsApp-based mathematics chatbot tutor, offering personalised exercises and conversational support. The use of WhatsApp is significant, given the platform's widespread adoption among secondary school learners (Rising Academies, 2023).

5 **Botify**: **AI bots** that answer mathematics questions, provide exam revision materials, and track students' progress. A community-driven initiative that illustrate the adaptability of AI chatbots for everyday mathematics support in classrooms (Botify, 2024).

6. **PrepClass**: It combine human tutoring with AI-enabled analytics and adaptive content delivery, helping secondary school learners prepare for national examinations. It demonstrates how technology-assisted instructional materials are being blended with traditional tutoring to enhance mathematics achievement in Nigeria (PrepClass, 2024).
7. **MATHia:** It is a widely-studied AI/ML-driven adaptive math tutor that gives real-time feedback, diagnoses misconceptions and sequences practice for mastery. It is an example of AI-designed instructional material used in secondary schools.

The theoretical framework that underpins this study is known as constructivist learning theory, which emphasizes active learner-centered instruction, in which students construct knowledge through experiences and interactions. AI systems under the constructivism theory help students build knowledge by providing customised activities designed for their present cognitive development. AI tools support this by offering personalised, interactive learning experiences that encourage exploration and critical thinking. Constructivism's core idea is that meaningful knowledge is actively constructed in cognitive, cultural, emotional, and social contexts through classroom engagement (Hwang et al., 2020). Integrating AI tools with constructivist principles can transform education by enhancing student engagement, self-reflection, and conceptual changes (Fawehinmi et al., 2025).

Students in secondary schools are usually are young people aged between 12 and 18 years, and are in the adolescence stage of development. Their growth and development is a crucial element as they transition to adulthood. The secondary education is a crucial foundation for the development of adolescents (Yi et al., 2023), and it is characterized by explorations and discoveries, which is common among adolescents. Among students in secondary schools, gender issues in science education have long been a topic of debate among science teachers. Ogoke et al (2018) argues that mathematics teachers often perpetuate gender stereotypes in the classroom, leading to differential treatment of boys and girls. This finding is consistent with the results of a study by Walter (2024), who discovered that no significant differences in students' mathematics performance based on gender.

Statements of the Problems

The issue of low achievement in mathematics among secondary school students is a global concern, with many countries experiencing similar challenges. The integration of AI in mathematics education has been identified as a potential solution to improve student outcomes. (Hwang et al., 2020). Research has shown that AI can be an effective tool in improving mathematics education. A study by Hwang et al. (2020), showed that AI-powered adaptive learning systems can lead to significant gains in mathematics achievement, particularly for struggling students.

Though, students are increasingly using modern technologies like laptops and smartphones, but these tools are not being fully leveraged to support mathematics learning. Despite efforts by government, parents and school authorities in enhancing good mathematics achievements among secondary school students, the problem of low mathematics performance persists (Fawehinmi et al., 2025). Studies had shown that AI can provide personalised learning experiences, real time feedback, and improved student outcomes. Therefore, this study examined effectiveness of AI-designed instructional materials on mathematics achievement of secondary school students in Lagos State.

Research Objectives

Specifically, this study seeks to:

(1) Determine the differences in mean achievement scores between students taught mathematics with AI-Designed Instructional Materials and those taught without AI-designed materials.

(2) Examine differences in mean mathematics achievement scores between male and female students.

Research Questions

1. Are students in secondary schools inclined to AI-designed instructional materials for mathematics in Lagos State?
2. Is there any difference in the means of mathematics achievement between male and female secondary school students in Lagos state?

Hypotheses

1. There is no significant effect of AI-Designed Instructional Materials on Mathematics Achievement of Secondary School Students in Lagos State
2. There is no significance difference in the means of Mathematics Achievement between male and female Secondary School Students in Lagos?

Methodology

This study employed a descriptive survey design. The study population included students in all secondary schools in Lagos State. The sample consisted of 312 students randomly selected from seven secondary schools in Lagos state. The research instrument was a structured questionnaire titled "*AI-Designed Instructional Materials for Mathematics Achievement Scale*' (AIMMAS), with three sections. Section A consisted of students' demographic data, Section B focused on adoption of AI-designed instructional materials, while section C consisted of students last session annual mathematics scores to obtain their achievement in mathematics. Responses to the items were measured using a 4-point Likert scale (Strongly Agree, Agree, Disagree, and Strongly Disagree). The self-administered questionnaires ensured high response rates. The validity and reliability of the questionnaire was established using multiple methods. Content validity was achieved through literature review and expert consultations. Reliability testing yielded a Cronbach's alpha of 0.87, indicating a high internal consistency. A pilot test and subsequent revisions strengthened the face and content validity. Data obtained was analysed using descriptive statistics of percentages, mean, standard deviation; and

inferential statistics of ANOVA and t-test, to test all stated hypotheses at 0.05 level of significance.

Result

Research Question 1. Are students in secondary schools inclined to AI-designed instructional materials for mathematics in Lagos State?

Table 1: Inclination Level of Students to AI-designed instructional materials for Mathematics Achievement in Lagos State

		Frequency	Percent	Cumulative Percent
Valid	Low	176	56.4	56.4
	Average	88	28.2	84.6
	High	48	15.4	100.0
	Total	312	100.0	

Table 1 revealed that student's level of inclination to AI-designed instructional materials for mathematics in Lagos State was low among 176 respondents which correspond to 56.4%, average among 88 respondents which correspond to 28.2%, while 48 respondents which correspond to 15.4% were highly inclined to AI-designed instructional materials for mathematics in Lagos State. This result showed that more than half of respondents have low level of inclination to AI-designed instructional materials for mathematics. This is a great concern to all stakeholders in the education industry.

Research Question 2: Is there any difference in the means of mathematics achievement between male and female secondary school students in Lagos state?

Table 2: Group Statistics of Students of Gender on Mathematics Achievement

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Maths Achievement	Male	145	48.17	17.683	1.468
	Female	167	49.05	15.860	1.227

From Table 2, the mean and standard deviation of students' mathematics achievement showed that male respondents had mean of 48.17 and S D= 17.68; while female respondents had mean of 49.05 and S D= 15.86. This result shows that their means are very close. The implication of this was that students' mathematics achievement was not gender-based.

Hypothesis 1: There is no significant effect of AI-designed instructional materials on mathematics achievement of secondary school students in Lagos State

Table 3: ANOVA of effect of AI-Designed Instructional Materials on Mathematics Achievement of Secondary School Students in Lagos State

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	79294.687	2	39647.344	1623.215	.000
Within Groups	7547.386	309	24.425		
Total	86842.074	311			

From Table 3, it was revealed that $F(2, 309) = 1623.215$, and that $p = 0.000$. Since the p-value of the F-ratio is less than 0.05, this then showed that there is statistically significant difference between the variables. Hence, the null hypothesis was rejected. That is, AI-designed instructional materials have significant effect on mathematics achievement of secondary school students in Lagos State.

Table 4 shows where the effect lie:

Table 4: Tukey HSD showing effect of AI-Designed Instructional Materials on Mathematics Achievement

Inclination Level	N	Subset for alpha = 0.05		
		1	2	3
Low	176	36.24		
Average	88		56.35	
High	48			79.94
Sig.		1.000	1.000	1.000

Table 4 showed that on the measure of mathematics achievement of secondary school students in Lagos State, respondents with low inclination to AI-designed instructional materials had mean of 36.24, those with average inclination had mean of 56.35, while those with high inclination had mean of 79.94. This therefore showed that students with high level of inclination to AI-designed instructional materials had highest mean on their mathematics achievement, and vice versa.

Hypothesis 2. There is no significance difference in the means of mathematics achievement between male and female secondary school students in Lagos?

Table 5: Independent Samples Test of influence of gender on Mathematics Achievement of Secondary School Students in Lagos

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	T	df	Sig. (2-tailed)	Mean Diff	Std. Error Diff
Maths Achievement	Equal variances assumed	3.493	.063	-.465	310	.643	-.882	1.899
	Equal variances not assumed			-.461	291.886	.645	-.882	1.914

Table 5 presented the results of an independent samples t-test examining the influence of gender on mathematics achievement among secondary school students in Lagos state. Levene's test for equality of variances was not significant, $F(1, 310) = 3.493$, $p = 0.063$, indicating that the assumption of equal variances was met. The t-test showed no statistically significant difference in mathematics achievement between male and female students, $t(310) = - 0.465$, $p = 0.643$. The mean difference of - 0.882 suggested that, on average, male and female students performed similarly. Therefore, the null hypothesis stating that gender has no significant influence on mathematics achievement among secondary school students in Lagos state was not rejected. In other words, students' mathematics achievement does not significantly differ based on gender among secondary school students in Lagos.

Discussion

This study examined effectiveness of AI-designed instructional materials on mathematics achievement of secondary school students in Lagos state. Result obtained showed that more than half of the respondents have low level of inclination to AI-designed instructional materials for mathematics. This agrees with George and Jaleel (2025), who stated that students who use AI-enhanced learning tools tend to perform better academically, particularly in subjects like mathematics and science, where adaptive learning systems are frequently applied, but a lot of them are not favourably disposed to its usage. The first hypothesis which stated that there is no significant effect of AI-designed instructional materials on mathematics achievement of secondary school students in Lagos State was rejected. That is, students' inclination to AI-designed instructional materials have tendency to enhance their mathematics achievement. This finding agrees with Ogoke et al. (2025), who found that AI-designed instructional materials for mathematics are various learning resources such as lessons, charts, worked examples, hints, practice sets, formative assessments, visualisations, feedback scripts, sequencing/adaptive pathways, or tutor agents that are created, adapted, or delivered by AI methods, and can significantly improve students learning and achievement in mathematics.

The second hypothesis which stated that there is no significance difference in the means of mathematics achievement between male and female secondary school students in Lagos was

not rejected. In other words, students' gender has nothing to do with their mathematics achievement. This finding is consistent with the results of a study by Walter (2024), who discovered that no significant differences in students' mathematics performance based on gender.

Recommendations

Based on the findings of this study, the following recommendations were made:

1. There is an urgent need for authorities in both public and private secondary schools to promote the utilisation of AI-designed instructional materials for teaching and learning of mathematics.
2. School authorities should make arrangement and provide for adequate funding for acquiring and maintaining AI-designed instructional materials for teaching and learning of mathematics.
3. Teachers in secondary should upskill themselves on how use to effectively use AI-designed instructional materials for the teaching and learning of mathematics.
4. Students in secondary schools should be encouraged and be ready to utilized AI-designed instructional materials for learning of mathematics.
5. Government at all levels should make adequate preparation for maintaining data privacy, security, protect students' personal information and ensuring cyber-security.

Conclusion

This study examined effectiveness of AI-designed instructional materials on mathematics achievement of secondary school students in Lagos state. The study showed that a lot of students have low inclination to learning mathematics using AI-designed instructional materials. There is therefore, the need for urgent sanitisation of both the staff and students of secondary schools on the merits of AI-designed instructional materials.

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