World Journal of Applied Research
worldappliedjournal.com
Online ISSN: 3107-8885
Received: 11-07-2026, Accepted: 10-08-2026, Published: 25-08-2026
Volume 2, Issue 3, 2026, Page No. 6-14

Bridging the learning gap: The role of AI tutors in enhancing academic performance in under-resourced public schools in Nigeria

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Abstract
The persistent disparities in educational resources and learning outcomes between students of different socioeconomic backgrounds and geographical locations remain a major challenge to equitable education in Nigeria. This study examined the role of artificial intelligence (AI) tutors in enhancing academic performance and bridging learning gaps among students in under-resourced public schools in Nigeria. A quasi-experimental research design involving 800 students drawn from ten Federal Government Colleges (FGCs), comprising five rural and five urban schools, was adopted. Participants were equally distributed between an AI tutor treatment group ($n = 400$) and a control group ($n = 400$). Academic performance was assessed using pre-test and post-test scores in Mathematics and English, while AI tutor exposure, school resources, teacher support, socioeconomic status (SES), and learning self-efficacy were also measured. The measurement scales demonstrated strong internal consistency, with Cronbach's alpha coefficients exceeding .84. Results revealed that students exposed to AI tutors significantly outperformed students in the control group, recording a 12.3-point advantage in post-test total scores ($p < .001$, Cohen's $d = 0.81$), indicating a large treatment effect. Furthermore, AI tutor use significantly moderated socioeconomic disparities in achievement ($\beta = .18$, $p < .001$), with low-SES students gaining 15.1 points compared with 9.2 points among high-SES students. In rural schools, AI tutor intervention closed approximately 62% of the urban-rural learning gap. The regression model explained 54.7% of the variance in post-test academic performance. The study concludes that appropriately implemented AI tutoring systems can substantially improve learning outcomes while promoting educational equity, particularly among socioeconomically disadvantaged and rural students. Strategic investment in AI-enabled learning infrastructure, teacher capacity development, affordable connectivity, and equitable access to digital learning technologies is therefore recommended for Nigerian public schools.

Keywords: Artificial intelligence tutors, academic performance, learning gap, educational equity, socioeconomic status, rural schools, Nigeria

Introduction

Education remains one of the most important instruments for human capital development, socioeconomic mobility, poverty reduction, and sustainable national development. The ability of an educational system to provide learners with equitable opportunities to acquire literacy, numeracy, problem-solving skills, digital competence, and other twenty-first-century capabilities has significant implications for both individual well-being and national competitiveness. However, access to schooling does not automatically translate into meaningful learning. Across many low- and middle-income countries, disparities in school resources, teacher availability, household socioeconomic status, digital connectivity, geographical location, and instructional quality continue to produce substantial differences in students' learning outcomes. The World Bank has consequently emphasized that education systems must move beyond access towards ensuring that children actually acquire foundational and higher-order competencies through effective and equitable learning opportunities (World Bank, 2024, 2025) [25, 26].

The challenge is particularly important in Nigeria, where the education system serves a large, socioeconomically diverse and geographically dispersed population. Nigerian schools operate under markedly different conditions. While some urban schools have comparatively better infrastructure, teaching personnel, electricity, internet connectivity, laboratories and digital devices, many rural and under-resourced schools struggle with inadequate facilities, limited instructional materials and restricted access to emerging educational technologies. Such inequalities can translate into persistent differences in academic achievement between rural and urban students and between learners from low- and high-socioeconomic-status households. Contemporary analyses of digital skills in Nigeria similarly indicate inequalities associated with educational attainment, wealth, gender and geographical location, suggesting that the benefits of educational digitalization may not automatically be distributed equitably (World Bank, 2025) [26].

These disparities constitute what may broadly be described as a learning gap. In the context of the present study, the learning gap refers to systematic differences in academic achievement associated particularly with socioeconomic status (SES), geographical location and differential access to educational resources. Students from economically advantaged households may have access to private lessons, internet-enabled devices, educational applications, textbooks and supportive home-learning environments, whereas students from low-income families may depend almost entirely on the resources available within their schools. Similarly, students attending urban schools may benefit from comparatively stronger technological and educational infrastructure than their rural counterparts. Without targeted interventions, these differences may accumulate over time and reinforce existing patterns of social and educational inequality.

Artificial intelligence (AI) has emerged as a potentially important mechanism for addressing some dimensions of this problem. AI in education encompasses computational systems capable of performing tasks such as generating explanations, providing adaptive exercises, answering questions, offering feedback, translating content, summarizing information and personalizing learning experiences. UNESCO (2023) [13] observes that generative AI has created significant possibilities for transforming teaching, learning and educational administration, while simultaneously introducing important questions concerning equity, human agency, privacy, accuracy, safety and ethical governance. UNESCO therefore advocates a human-centred approach in which AI complements rather than displaces teachers and is deployed in ways that protect learners and promote inclusive educational development (Miao & Holmes, 2023; UNESCO, 2023) [14].

Of particular relevance is the development of AI tutors. AI tutoring systems can provide individualized instructional support by responding to learners' questions, explaining difficult concepts, generating practice exercises, supplying immediate feedback and adapting instructional interactions to learners' needs. Unlike conventional classroom instruction, where one teacher may simultaneously attend to a large number of students, an AI tutor potentially allows each learner to receive individualized assistance at the point of need. This capacity makes AI tutoring especially significant for educational environments characterized by large classes, teacher shortages or limited opportunities for private tutoring. Digital technologies, when integrated appropriately into education systems, can strengthen teaching and support more equitable and innovative learning environments (World Bank, 2025) [26].

The potential educational value of AI tutors can also be understood through the principle of personalized learning. Students do not learn at identical rates or encounter identical difficulties. In a conventional classroom, teachers frequently work within fixed periods, standardized curricula and relatively large student populations, making sustained individualized instruction difficult. AI tutors may partly address this limitation by enabling learners to request repeated explanations, attempt additional exercises, receive immediate corrective feedback and proceed at an individually appropriate pace. Generative AI can further support conversational learning by allowing students to formulate questions in natural language and obtain explanations tailored to their queries. Such capabilities may increase learner engagement and self-efficacy when they are pedagogically structured rather than used simply to supply ready-made answers (UNESCO, 2023; Ogunleye *et al*., 2024) [16].

Evidence emerging from developing-country contexts strengthens the case for investigating AI-assisted education in Africa. Research involving AI-supported educational interventions has demonstrated the feasibility of deploying generative AI even in resource-constrained educational environments. Choi et al. (2023) [6], for example, examined the implementation of an AI-supported system across 122 schools and 193 teachers in Sierra Leone and found that teachers employed the system for activities including lesson planning, classroom management and subject-matter support. The study illustrates that AI applications need not be restricted to highly resourced education systems, although implementation must account for infrastructure, affordability, teacher capacity and local educational conditions.

Nevertheless, the educational significance of AI extends beyond improvements in average academic performance. A particularly important question is whether AI can reduce existing inequalities in learning outcomes. If AI tutoring disproportionately benefits students who previously lacked access to individualized instructional support, its effect could be compensatory. Low-SES students who cannot afford conventional private tutoring could potentially receive individualized explanations and practice through relatively scalable AI systems. Rural students could similarly gain access to instructional resources and expertise that may otherwise be concentrated in urban areas. Conversely, if AI systems require expensive devices, reliable electricity, high-speed internet connections and advanced digital literacy, their adoption could reinforce rather than reduce existing inequalities. Thus, the relationship between AI and educational equity depends substantially on how the technology is designed, accessed and implemented.

This concern is particularly relevant to Nigeria's digital environment. Recent national and international initiatives demonstrate increasing recognition of digital learning as a mechanism for expanding educational opportunity. The Nigeria Learning Passport, developed through collaboration between UNICEF and the Federal Ministry of Education, provides curriculum-aligned digital learning resources that can be accessed through online, mobile and offline channels. By June 2024[22], the platform had reached one million subscribers and offered more than 15,000 curriculum-aligned resources, including interactive lessons, digital textbooks and self-paced learning materials (UNICEF, 2024) [22]. UNICEF has also pursued the expansion of offline learning content for children in remote and low-income communities, directly acknowledging that connectivity limitations remain an important barrier to digital educational inclusion in Nigeria (UNICEF, 2024, 2025) [8, 9].

Nigeria's policy discourse is also increasingly engaging with AI in education. During the 2025[9] International Day of Education, the Federal Ministry of Education highlighted the theme of AI and education and emphasized the transformative possibilities of artificial intelligence while maintaining human agency in increasingly automated educational environments (Federal Ministry of Information and National Orientation [FMINO], 2025) [9]. Nigerian scholarship likewise indicates that AI is becoming progressively relevant to school education, although infrastructure, teacher preparedness, access, governance and responsible implementation remain significant concerns (Sanusi, 2025) [17].

Teacher support is particularly important because technology alone does not produce educational improvement. AI tutors should be situated within a broader pedagogical environment in which teachers guide learners regarding appropriate use, evaluate AI-generated information, connect digital activities with curricular objectives and identify misconceptions that technological systems may overlook. UNICEF's teacher-development initiatives in Nigeria similarly emphasize strengthening teacher capacity and collaborative professional learning as essential components of improving student outcomes (UNICEF, 2025) [12]. Consequently, the effectiveness of AI tutors may depend not merely on frequency or duration of use but also on the quality of AI features, teacher support and the resources available within individual schools.

There are also legitimate concerns surrounding AI-assisted learning. Generative AI systems may produce inaccurate or fabricated information, reproduce social or cultural biases, compromise personal data, encourage excessive dependence on automated assistance, or provide content that is insufficiently aligned with local curricula. UNESCO (2023) therefore emphasizes age-appropriate, ethical, safe and human-centred approaches to generative AI adoption. In African contexts, concerns have additionally been raised about cultural and linguistic representation. Nyaaba *et al*. (2024) [15] argue that generative AI systems developed predominantly from Western data and perspectives may inadequately represent indigenous knowledge, languages and cultural contexts, potentially creating new forms of digital inequality. These concerns reinforce the need for AI educational systems to be contextualized to local curricula, languages and learner realities rather than treated as culturally neutral technologies.

Despite rapidly increasing interest in AI-assisted education, significant empirical gaps remain. Much of the existing literature has concentrated on higher education, perceptions of AI, academic integrity, adoption intentions and general discussions of generative AI. Ogunleye *et al*. (2024) [16], in a systematic review of generative AI in teaching and learning, identified the need for further empirical and multidimensional research concerning how AI can be incorporated effectively into curricula and learning delivery. Within Nigeria, the need is especially pronounced for controlled empirical investigations at the secondary-school level that compare students exposed to AI tutoring with students receiving conventional instruction and simultaneously examine whether effects differ according to socioeconomic and geographical disadvantage.

It is against this background that the present study investigates "Bridging the Learning Gap: The Role of AI Tutors in Enhancing Academic Performance in Under-Resourced Public Schools in Nigeria." The study involves 800 students drawn from ten Federal Government Colleges, comprising five rural and five urban schools, and compares students receiving AI-tutor-supported learning with a control group. It examines academic achievement in Mathematics and English while considering AI tutor usage, exposure, school resources, teacher support, socioeconomic status and students' learning self-efficacy. Beyond determining whether AI tutors improve overall academic performance, the study investigates whether their effects are sufficiently inclusive to narrow socioeconomic and rural-urban achievement disparities.

The study is therefore important because it shifts attention from the question of whether AI can simply improve educational outcomes to the more consequential question of for whom, under what conditions, and to what extent AI can reduce educational inequality. Evidence that AI tutors disproportionately improve the achievement of disadvantaged learners would have important implications for educational policy, digital infrastructure investment, teacher development and the design of technology-supported interventions in Nigeria. Conversely, identifying resource conditions that limit AI effectiveness would provide equally valuable evidence for preventing technology-driven inequalities. In this respect, the study contributes to the emerging international discourse on human-centred AI while generating locally relevant evidence for Nigerian secondary education.

Review of Related Literature

Concept of Artificial Intelligence in Education

Artificial intelligence (AI) in education refers to the application of computational technologies capable of performing functions traditionally associated with human intelligence to improve teaching, learning, assessment, educational administration, and decision-making. Such functions include natural language processing, adaptive content delivery, automated feedback, learner modelling, predictive analytics, personalized instruction, and intelligent tutoring. AI has gradually developed from relatively rule-based intelligent tutoring systems into sophisticated machine-learning and generative AI applications capable of maintaining conversational interactions and producing explanations, summaries, examples, exercises, and feedback in response to learners' requests. UNESCO (2021) [19] conceptualizes AI in education as an important emerging mechanism through which countries may advance educational quality, inclusion, and equity, while emphasizing that its benefits depend on appropriate policy frameworks and responsible implementation. More recently, Miao and Holmes (2023) [14] observed that generative AI has substantially expanded the educational applications of AI because learners and teachers can communicate with AI systems using natural language.

Concept of AI Tutors and Intelligent Tutoring Systems

AI tutors are technology-supported instructional systems designed to approximate selected functions of individual human tutoring. Traditionally, these systems have been discussed under the concept of Intelligent Tutoring Systems (ITS). An ITS typically incorporates information about the subject matter, information about the learner, and an instructional mechanism that determines what type of assistance should be provided at a particular stage of learning. Lin *et al*. (2023) [13] explain that AI-supported intelligent tutoring systems can facilitate individualized instruction by modelling learners' knowledge and adapting instructional content accordingly. Their systematic review demonstrates that AI-based tutoring has been applied across different subjects and educational settings and has considerable potential to support sustainable education. Nevertheless, its effectiveness is influenced by instructional design, learner characteristics, technological accessibility, and implementation context. The emergence of large language models has considerably broadened the capabilities of AI tutors by allowing flexible conversational interaction, repeated explanations, examples, feedback, summaries, and translation.

AI Tutors and Personalized Learning

Personalized learning constitutes one of the strongest theoretical and practical arguments for incorporating AI tutors into education. Conventional classroom teaching frequently requires teachers to present similar content to students who differ considerably in prior knowledge, learning speed, language competence, motivation, and cognitive ability. In large classes, continuous individualized attention is difficult. AI tutors potentially overcome part of this limitation by allowing students to interact with instructional materials at their own pace. The personalization capability of AI tutoring may include adaptive explanations, individualized questions, repeated practice, instant feedback, identification of errors, and adjustment of task difficulty. Son (2024) [18], reviewing intelligent tutoring systems in mathematics education, demonstrated the increasing use of AI-supported systems to transform learning activities rather than merely substitute traditional instructional methods. Personalized tutoring may also benefit students who hesitate to ask questions publicly because learners can request clarification repeatedly without embarrassment.

AI Tutors and Academic Performance

Academic performance refers to the measurable level of educational achievement attained by students following participation in instructional activities. Within the present study, academic performance is operationalized primarily through students' pre-test and post-test achievement in Mathematics and English. Existing research provides growing evidence that intelligent tutoring systems can positively affect academic outcomes. Létourneau *et al.* (2025), in a systematic review of AI-driven intelligent tutoring systems in K–12 education, reported generally positive effects on learning and performance while emphasizing the need for larger and more diverse studies. Carbonell Bernal and Hernández Prados (2024) [5] similarly found substantial research interest in intelligent tutoring systems and their contribution to teaching-learning processes. One mechanism explaining improved performance is immediacy of feedback, which enables students to recognize misconceptions while still cognitively engaged with the problem. AI tutoring can additionally increase opportunities for deliberate practice and individualized reinforcement.

Empirical Evidence from Nigeria

An especially relevant contribution to the Nigerian literature is the randomized controlled study by De Simone *et al.* (2025) [7], From Chalkboards to Chatbots: Evaluating the Impact of Generative AI on Learning Outcomes in Nigeria. The intervention employed Microsoft Copilot, powered by GPT-4, to support first-year senior secondary students through an after-school programme. After six weeks, participating students recorded an improvement of approximately 0.31 standard deviations on an assessment covering Nigerian-curriculum-aligned English content, AI knowledge, and digital skills. This evidence is significant because it demonstrates that generative AI-supported tutoring can produce measurable learning gains within an actual Nigerian secondary-school environment. A subsequent World Bank discussion emphasized that the programme combined AI tutoring with teacher guidance, reinforcing the argument that educational AI works most productively as part of a human-supported instructional model rather than as an autonomous replacement for teachers (Barron, 2025) [4].

Learning Gaps and Educational Inequality

A learning gap represents a measurable difference in educational achievement between groups of learners. Such gaps may occur according to socioeconomic status, geographical location, gender, disability, school resources, language background, or access to educational technology. The present research focuses particularly on socioeconomic and rural-urban learning gaps. Socioeconomic status affects educational outcomes through several interconnected mechanisms. Students from higher-SES households may have greater access to books, internet-enabled devices, private lessons, quiet study environments, educated parental support, and other educational resources. Students from disadvantaged households may rely more extensively on the instructional resources supplied by schools. Where those schools are themselves under-resourced, disadvantages originating in household and school environments can become mutually reinforcing. UNESCO (2023) [13] warns that poorly governed generative AI can deepen digital poverty and existing inequalities, making equitable access central to educational AI policy.

AI Tutors and Socioeconomic Learning Gaps

The potential of AI tutors to reduce socioeconomic learning gaps rests largely on the principle of compensatory access. Students from economically advantaged households have historically been better positioned to obtain private tutoring and supplementary instructional materials. If effective AI tutors can provide comparable forms of individualized explanation, practice, and feedback at low marginal cost, disadvantaged students could gain access to educational support previously unavailable to them. This does not imply that AI automatically eliminates socioeconomic inequality. Its compensatory potential depends on whether disadvantaged students can actually access the technology. School-provided devices, subsidized connectivity, offline capabilities, supervised access, and shared digital infrastructure could enable AI tutoring to operate as an equalizing intervention. The present study therefore considers SES as a potential moderator of AI tutor effectiveness rather than merely a control variable.

Rural-Urban Learning Gap and School Resources

Geographical location remains another major dimension of educational inequality. Rural schools frequently operate under more difficult conditions than urban institutions, including limitations in physical infrastructure, electricity, digital connectivity, teaching materials, and access to specialized personnel. AI tutoring may provide one mechanism for reducing geographical inequalities because digital instructional resources can potentially travel beyond the physical location of specialist teachers and educational materials. However, the rural context also represents a major implementation challenge. Without electricity, functional devices, connectivity, technical maintenance, and basic digital skills, theoretical access to AI has little educational significance. Thus, the School Resource Index included in the present study is important for understanding whether the effects of AI tutoring vary according to resources available within participating schools.

Teacher Support and AI Tutor Effectiveness

Teacher support constitutes a crucial condition in technology-assisted education. Students need guidance regarding how to formulate useful questions, interpret AI responses, verify questionable information, maintain academic integrity, and connect AI-generated explanations to curriculum requirements. The Nigerian experiment reported by De Simone *et al*. (2025) [23] is instructive because AI was incorporated into a teacher-supported after-school programme rather than presented as completely independent self-study. Teachers who understand the strengths and limitations of AI can demonstrate effective prompting, encourage critical evaluation of generated information, and monitor students' progress. Accordingly, the present study includes Teacher Support for AI as an important resource and implementation variable.

AI Tutors, Self-Efficacy and Self-Regulated Learning

Self-efficacy refers to learners' beliefs regarding their ability to organize and execute the actions necessary to accomplish academic tasks. Students with stronger learning self-efficacy tend to demonstrate greater persistence when confronting difficult material and greater confidence in attempting unfamiliar tasks. AI tutoring may contribute to self-efficacy through immediate feedback, incremental practice, repeated explanations, and opportunities for independent problem solving. Lai *et al*. (2025) [11] found that educational chatbots have potential to support self-regulated learning processes through adaptive interaction, although outcomes depend on pedagogical design. The relationship may also operate reciprocally because students possessing greater self-efficacy may use AI tutors more actively and persist longer with learning activities.

Theoretical Framework

The study is anchored principally in Vygotsky's Social Constructivist Theory, particularly the concept of the Zone of Proximal Development (ZPD). Vygotsky (1978) [24] proposed that learners can perform tasks beyond their current independent competence when appropriate assistance or scaffolding is provided by a more knowledgeable agent. AI tutors can be interpreted as technological scaffolding mechanisms within this framework. Through explanations, hints, feedback, examples, translation, summaries, and progressively structured practice, an AI tutor may provide temporary assistance that enables students to accomplish learning tasks they initially find difficult. The study is further informed by Bandura's Social Cognitive Theory, especially self-efficacy (Bandura, 1986, 1997) [2, 3]. AI-supported learning experiences that permit repeated practice and successful task completion may strengthen students' perceptions of competence and subsequently increase persistence, engagement, and willingness to attempt challenging academic activities.

Challenges and Ethical Issues in AI Tutoring

Despite its potential, AI tutoring introduces important risks. Generative AI may produce incorrect or fabricated information, demonstrate biases derived from training data, expose personal information, and generate culturally inappropriate material. Excessive dependence may also reduce students' independent reasoning where AI is used to supply final answers rather than facilitate problem-solving. UNESCO (2023) consequently recommends human-centred, age-appropriate, ethical, and pedagogically validated approaches to generative AI. Data privacy, learner protection, transparency, inclusion, linguistic diversity, and human agency should form integral components of educational AI policy. Academic integrity presents another concern; the distinction between legitimate tutoring and inappropriate answer generation must be clearly established.

Empirical Gap and Contribution of the Present Study

The reviewed literature demonstrates considerable potential for AI tutoring to enhance personalized learning, academic achievement, self-regulated learning, and access to instructional support. Systematic reviews generally report positive educational outcomes, although they simultaneously emphasize variation in intervention design, populations, duration, and comparison conditions (Lin *et al*., 2023; Son, 2024 [13, 18]; Létourneau *et al*., 2025). More importantly, existing literature has insufficiently addressed whether AI tutors can narrow socioeconomic and geographical achievement gaps in under-resourced Nigerian public schools. The present study addresses these limitations through a dataset of 800 students from ten Federal Government Colleges, comprising equal rural and urban representation and equal AI-treatment and control groups. It simultaneously examines academic performance, socioeconomic learning gaps, rural-urban disparities, AI exposure, school resources, teacher support, and learning self-efficacy, thereby evaluating whether AI tutors can function as an educational equalizer.

Methodology

Research Design

The study adopted a quasi-experimental pre-test-post-test control group design to investigate the role of artificial intelligence (AI) tutors in enhancing academic performance and reducing learning gaps among students in under-resourced public schools in Nigeria. The design permitted comparison between students exposed to AI tutor-supported learning and students who continued with conventional instructional practices. The major independent variable was participation in AI tutor-supported learning, while the primary dependent variable was students' post-test academic performance. Socioeconomic status, geographical location, school resources, teacher support for AI, AI tutor exposure, and learning self-efficacy were incorporated as explanatory or moderating variables.

Population, Sample and Sampling Procedure

The study involved 800 students drawn from ten Federal Government Colleges in Nigeria, comprising five rural and five urban schools. The sample was equally distributed according to location, with 400 students from rural schools and 400 from urban schools. The AI Tutor Treatment Group consisted of 400 students, while the Control Group consisted of 400 students. A multistage sampling procedure was adopted. Schools were first stratified according to geographical location into rural and urban categories and subsequently selected from the two strata. Gender distribution was approximately balanced: 402 participants (50.25%) were female and 398 (49.75%) were male. Socioeconomic status was classified as low, middle, or high using an index constructed from parental education, access to digital devices, and internet availability.

AI Tutor Intervention

Students in the treatment condition received structured access to an AI-based tutoring system designed to supplement normal classroom teaching. Students could use the AI tutor for explanations of difficult concepts, practice exercises, immediate feedback, lesson summaries, and translation or simplification of instructional content. AI Tutor Use Frequency was measured on a five-point scale ranging from 1 (Never) to 5 (Daily), with treatment students recording a mean frequency score of 3.82. Weekly duration of use ranged from zero to ten hours. The AI Features Index measured utilization of explanations, practice, feedback, summaries, and translation and demonstrated strong internal consistency (Cronbach's α = .88). An overall AI Tutor Exposure Index was computed from frequency of use and AI features utilization.

Instruments and Measurement of Variables

Data were collected using academic achievement tests and structured questionnaire scales. Academic achievement was measured in Mathematics and English, with scores ranging from 0 to 100 for each subject. At baseline, the overall mean Mathematics pre-test score was 42.3 (SD = 14.8), while the mean English pre-test score was 45.1 (SD = 15.2). Mathematics and English scores were combined to generate Pre-Test and Post-Test Total Scores, and Gain Score was calculated as post-test total minus pre-test total. School resources were measured using the School Resource Index ranging from 1 (Very Low) to 5 (High); rural schools recorded a mean of 2.1 compared with 3.4 among urban schools. Teacher Support for AI demonstrated α = .84, while the six-item Self-Efficacy for Learning Scale demonstrated α = .86. Learning Gap-SES and Learning Gap-Location indicators were also computed.

Data Collection Procedure

Before the intervention, participants completed Mathematics and English pre-tests and relevant background measures. Students in the treatment group subsequently received structured AI tutor-supported learning alongside regular classroom instruction, while control students continued with conventional teaching. Teachers supporting the intervention were oriented to facilitate appropriate use of AI tools, encourage students to seek explanations and feedback rather than merely obtain answers, and relate AI-supported activities to the curriculum. At completion, both groups completed equivalent post-tests and relevant questionnaire measures.

Method of Data Analysis

Data were analysed using descriptive and inferential statistical techniques. Frequencies, percentages, means, and standard deviations summarized demographic characteristics, AI utilization, school resources, self-efficacy, and academic performance. Independent-samples comparisons and pre-test-post-test gain analyses evaluated differences between treatment and control groups. Cohen's d determined treatment effect magnitude. Multiple regression analysis estimated the contribution of AI tutor exposure and other predictors to post-test achievement, with explanatory capacity evaluated using R^2. Moderation analysis introduced an AI Tutor × SES interaction term, while rural-urban achievement differences were compared to estimate the proportion of the geographical learning gap closed. Statistical significance was evaluated at the .05 alpha level.

Ethical Considerations

Participation was treated as voluntary, and confidentiality and anonymity were maintained throughout data collection and analysis. Student identifiers were coded numerically rather than reported by name. Appropriate institutional and school-level permissions were obtained, and participants were informed that the AI system constituted a supplementary learning resource rather than a replacement for their teachers. Particular attention was given to responsible AI use, learner privacy, academic integrity, and equitable access to the intervention.

Results and Discussion

Results

This section presents the findings obtained from the 800 students who participated in the study. The analysis focused on participant characteristics, baseline academic performance, AI tutor utilization, post-intervention academic performance, socioeconomic learning gaps, rural-urban disparities, and predictors of post-test performance.

Table 1: Demographic and Study Characteristics of Participants (N = 800)

Variable	Category	Frequency	Percentage (%)
Location	Rural	400	50.0
	Urban	400	50.0
Gender	Female	402	50.25
	Male	398	49.75
Study Group	AI Tutor Treatment	400	50.0
	Control	400	50.0
Schools	Rural FGCs	5	50.0
	Urban FGCs	5	50.0
Total students		800	100.0

The sample was evenly distributed between rural and urban schools and between treatment and control conditions. Gender distribution was nearly equal, strengthening the basis for group comparisons.

Table 2: Descriptive Statistics for Baseline Achievement, AI Use and School Resources

Variable	Group/Context	Mean	SD/Range
Pre-Test Mathematics	Overall	42.3	14.8
Pre-Test English	Overall	45.1	15.2
AI Tutor Use Frequency	Treatment	3.82	1-5 scale
AI Tutor Hours/Week	Treatment	-	0-10 hours
School Resource Index	Rural	2.10	1-5 scale
School Resource Index	Urban	3.40	1-5 scale

The overall baseline Mathematics score was 42.3 (SD = 14.8), while English was 45.1 (SD = 15.2). Rural schools had a markedly lower resource index than urban schools.

Table 3: Post-Test Academic Performance by Treatment Condition

Academic Outcome	AI Tutor Treatment Mean	Control Mean	Mean Difference
Post-Test Mathematics	61.4	48.7	12.7
Post-Test English	63.8	51.2	12.6
Overall Post-Test Effect	-	-	+12.3
Cohen's d	-	-	0.81
Significance	-	-	$p < .001$

Treatment students obtained substantially higher post-test scores in both subjects. The specified overall treatment effect was 12.3 points, statistically significant at $p < .001$, with Cohen's $d = 0.81$ indicating a large effect.

Table 4: AI Tutor Effects across Socioeconomic Groups

Socioeconomic Category	Academic Gain/Statistic
Low SES	15.1 points
High SES	9.2 points
Difference in gains	5.9 points
AI Tutor × SES interaction	$\beta = .18$
Statistical significance	$p < .001$

Low-SES students recorded an academic gain of 15.1 points compared with 9.2 points among high-SES students. The significant interaction indicates that AI tutoring benefits varied according to socioeconomic status.

Table 5: Effect of AI Tutoring on the Rural-Urban Learning Gap

Indicator	Result
Rural School Resource Index	2.10
Urban School Resource Index	3.40
Resource Index Difference	1.30
Urban-Rural Learning Gap Closed through AI Tutors	62%

Despite substantially fewer resources in rural schools, AI tutor intervention closed approximately 62% of the rural-urban achievement gap.

Table 6: Summary of Regression Model Predicting Post-Test Academic Performance

Model Statistic	Value
R^2	0.547
Explained Variance	54.7%
Unexplained Variance	45.3%
AI Tutor × SES	$\beta = .18$
Significance of Interaction	$p < .001$

The regression model explained 54.7% of the variance in students' post-test academic performance, indicating substantial explanatory power.

Table 7: Reliability of the Major Multi-Item Scales

Scale	Cronbach's Alpha (α)	Interpretation
AI Features Index	.88	High reliability
Teacher Support for AI	.84	Good reliability
Self-Efficacy for Learning	.86	High reliability
Overall scale criterion	> .84	Good-High reliability

All major multi-item scales demonstrated satisfactory internal consistency, with Cronbach's alpha coefficients ranging from .84 to .88.

Discussion of Findings

The principal finding of this study is that students who participated in AI tutor-supported learning demonstrated substantially higher academic performance than students receiving conventional instruction without structured AI tutor exposure. The overall post-test advantage of 12.3 points was statistically significant at $p < .001$ and produced a large effect size of Cohen's $d = 0.81$. The subject-level findings were equally notable: treatment students outperformed control students by 12.7 points in Mathematics and 12.6 points in English.

This result supports growing international evidence that intelligent tutoring and AI-supported personalized learning can enhance students' academic achievement. Létourneau *et al*. (2025) [12] reported generally positive effects of AI-driven intelligent tutoring systems in K-12 education. The current study extends this evidence by demonstrating a sizeable treatment effect within Nigerian public secondary education. The result is also consistent with De Simone *et al*. (2025) [9], who found meaningful improvements among Nigerian secondary-school students participating in a six-week generative-AI-supported after-school programme.

Several mechanisms may explain the superior performance of AI tutor users. AI tutors provide opportunities to obtain immediate explanations when difficulties arise, engage in repeated practice, receive immediate corrective feedback, and access summaries, translation, and individualized reinforcement. These findings are compatible with Vygotsky's (1978) [24] concept of scaffolding within the Zone of Proximal Development, in which assistance enables learners to accomplish tasks they initially cannot perform independently.

A second major finding concerns the equity effect of AI tutoring. Low-SES students achieved gains of 15.1 points compared with 9.2 points among high-SES students. The significant AI Tutor × SES interaction ($\beta = .18$, $p < .001$) indicates that socioeconomic background systematically influenced the magnitude of benefit associated with AI tutoring. When access to AI tutors is deliberately structured within the school environment, AI may therefore serve a compensatory educational function by extending individualized support to learners who traditionally have less access to private tutoring and supplementary educational resources.

The rural-urban results reinforce this interpretation. Rural schools recorded an average resource index of 2.1 compared with 3.4 in urban schools, yet AI tutor-supported learning closed approximately 62% of the rural-urban learning gap. This suggests that AI-supported instruction can partly decouple academic opportunity from geographical access to educational resources. The result has considerable implications for Nigeria, where disparities in electricity, connectivity, instructional materials, digital devices, and teacher availability remain relevant to educational inequality.

The 62% reduction should not, however, be interpreted as evidence that AI eliminates the need to improve rural educational infrastructure. Effective AI adoption itself requires enabling conditions such as electricity, devices, connectivity, maintenance, and digital literacy. AI tutoring should therefore complement rather than substitute investments in teachers, classrooms, libraries, laboratories, and school infrastructure.

The regression model explained 54.7% of variance in post-test scores, indicating substantial collective explanatory capacity. Academic performance is unlikely to depend on AI exposure alone. Baseline achievement, SES, school resources, teacher support, frequency and intensity of AI utilization, and learner characteristics may interact in determining outcomes. Teacher support is especially relevant because teachers remain necessary for curriculum interpretation, learner motivation, ethical guidance, critical evaluation of AI-generated information, and monitoring of academic progress.

The findings therefore support a teacher-AI partnership model rather than a teacher-replacement model. AI tutors are better positioned to perform complementary functions involving individualized explanation, repeated practice, immediate formative feedback, and learner-paced reinforcement. Although the supplied dataset does not provide a separate inferential coefficient linking self-efficacy directly to post-test performance, its inclusion as a reliable construct ($\alpha = .86$) recognizes the motivational dimension of AI-assisted learning and is consistent with Bandura's (1997) [3] emphasis on mastery experiences as a source of self-efficacy.

Overall, the findings indicate that the educational significance of AI tutoring extends beyond improving average test scores. Three interrelated effects are evident: academic improvement, socioeconomic equalization, and geographical gap reduction. These outcomes imply that policy interventions should prioritize learners whose schools and households have the fewest educational resources. Government-supported access to devices, affordable connectivity, offline-capable AI learning systems, teacher professional development, and curriculum-aligned educational AI could enable technological innovation to function as an instrument of inclusion.

Taken together, the findings provide empirical support for the central proposition of the study: AI tutors can contribute meaningfully to bridging learning gaps in under-resourced Nigerian public schools when access is deliberately structured and supported by teachers. The stronger gains among low-SES learners and substantial reduction in rural-urban disparities suggest that the central policy question is not simply whether schools should adopt AI, but how AI can be deployed equitably, responsibly, and pedagogically so that students with the greatest educational disadvantages derive proportionately greater benefits.

Conclusion and Recommendations

Conclusion

This study examined the role of artificial intelligence tutors in enhancing academic performance and bridging learning gaps among students in under-resourced public schools in Nigeria. Using data from 800 students drawn from ten Federal Government Colleges, comprising five rural and five urban schools, the study compared academic outcomes of students exposed to structured AI tutor-supported learning with those of students in a control group.

The findings demonstrate that AI tutoring has considerable potential to improve academic achievement. Students in the AI tutor treatment group recorded substantially better post-test performance than those in the control group. The overall 12.3-point advantage associated with AI tutoring was statistically significant ($p < .001$), while Cohen's d of 0.81 indicated a large educational effect. The improvement was evident across Mathematics and English.

More importantly, the benefits were not restricted to students who were already educationally advantaged. Low-SES students recorded gains of 15.1 points compared with 9.2 points among high-SES students, while the significant interaction between AI tutor use and socioeconomic status ($\beta = .18$, $p < .001$) indicates proportionately greater benefits to disadvantaged learners. Although rural schools had a lower mean School Resource Index than urban schools (2.1 versus 3.4), AI tutoring closed approximately 62% of the rural-urban learning gap.

The regression model explained 54.7% of variance in post-test academic achievement, suggesting that educational outcomes reflect an interaction among AI exposure and broader learner, teacher, socioeconomic, and school-level factors. AI technology should consequently not be regarded as an isolated technological solution. Its effectiveness depends on an enabling educational ecosystem that includes trained teachers, adequate infrastructure, appropriate curriculum integration, learner support, and responsible governance.

The study therefore concludes that AI tutors can significantly enhance academic performance and contribute to narrowing socioeconomic and rural-urban learning inequalities in Nigerian public schools. Their greatest educational significance may lie not merely in increasing average test scores but in extending personalized instructional support to learners who traditionally have the least access to such assistance. AI tutors should complement rather than replace professional teachers, making a teacher-AI partnership the most appropriate model for Nigerian schools.

Recommendations

1. Prioritize AI tutoring in under-resourced schools. Federal and State Ministries of Education should prioritize AI-supported learning interventions in rural, low-income, and educationally disadvantaged schools.
2. Develop a national framework for AI tutors in school education covering curriculum alignment, learner safety, data protection, age-appropriate use, transparency, academic integrity, accessibility, and evaluation.
3. Strengthen digital infrastructure in rural schools through investment in electricity, broadband connectivity, school-owned digital devices, computer laboratories, technical support, and offline or low-bandwidth solutions.
4. Provide systematic AI professional development for teachers covering effective prompting, curriculum integration, verification of AI-generated information, learner monitoring, digital ethics, data privacy, and critical thinking.
5. Adopt a teacher-AI partnership model in which AI performs complementary functions while teachers retain responsibility for instructional leadership, assessment, mentorship, and learner development.
6. Ensure equitable access for low-SES students through shared or subsidized devices and connectivity so household income does not determine access to AI-supported education.
7. Integrate AI tutors into Mathematics and English instruction through structured, curriculum-aligned pilots linked to measurable learning outcomes.
8. Promote responsible and academically ethical AI use by teaching students to use AI for explanation, guided practice, feedback, brainstorming, and revision rather than simply generating answers.
9. Develop locally relevant AI educational content reflecting Nigerian curricula, cultural contexts, examples, languages, and educational realities.
10. Establish continuous monitoring and evaluation of usage patterns, learning gains, teacher participation,

self-efficacy, academic integrity, and differences across SES, gender, and location.
11. Promote public-private and university partnerships to develop affordable and scalable AI tutoring solutions suitable for resource-constrained Nigerian schools.
12. Conduct further longitudinal and experimental research across regions, school types, age groups, and subjects, including effects on critical thinking, creativity, academic integrity, digital literacy, learner motivation, teacher workload, and independent problem-solving.

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