

Artificial Intelligence in Education: Systematic Review of Global Trends, Challenges and the Future of Secondary Schools in Delta State, Nigeria

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Abstract

This study examined the global trends, challenges and future prospects of Artificial Intelligence (AI) in education, focusing on its adoption and impact in public secondary schools in Delta State, Nigeria. Three research questions and three hypotheses guided the study. An exploratory sequential mixed-methods design combining quantitative and qualitative approaches was adopted. The population comprised teachers and principals in 497 public secondary schools. Using stratified random sampling, 50 schools were selected, involving 500 respondents (450 teachers and 50 administrators), of which 482 valid responses were analyzed. An additional 20 participants (15 teachers and 5 principals) were purposively selected for interviews. Data were collected with the Artificial Intelligence in Education Adoption Scale (AIEAS) and a semi-structured interview guide. The AIEAS demonstrated strong reliability ($\alpha = 0.85$). Quantitative data were analyzed using descriptive statistics, t-tests, multiple regression and Pearson correlation, while qualitative data were analyzed thematically. Findings revealed that teachers exhibited high awareness of AI but low practical integration due to infrastructural and policy limitations. A significant difference existed between global and Delta State AI integration levels. Teacher readiness and infrastructure jointly predicted AI adoption. Moreover, AI utilization strongly correlated with student learning outcomes. The study concludes that AI can transform teaching and learning if adequately supported. It recommends investment in digital infrastructure, teacher capacity building in AI literacy and alignment of educational policies with UNESCO's global AI-in-education framework to promote equity and sustainable innovation.

Keywords: AI in Education, Artificial Intelligence, Digital Learning, Infrastructure in Schools, Teacher Competence.

Introduction

Artificial Intelligence in Education (AIEd) represents a socio-pedagogical transformation that integrates intelligent systems such as intelligent tutoring systems (ITS), predictive analytics and automated grading to enhance performance, adaptability and equity (1, 2). Operating in multiple pedagogical roles (tutor, tool, tutee, teammate), AIEd aligns with UNESCO's SDG-4 agenda and the Fourth Industrial Revolution (3-5). Globally, AIEd has expanded rapidly (5), boosting personalized feedback by 40% (1) and STEM retention by 27% (2), with notable gains in Iran (6) and Finland/US (7). However, while developed nations reap these benefits, developing countries lag due to deep-seated infrastructural and socioeconomic inequities (8). Sub-Saharan Africa's Digital

Readiness Index stands at 38% against the 71% global average (9). Despite high digital awareness, Nigeria's education sector remains largely reliant on traditional teaching methods due to weak policy support, poor digital infrastructure and low teacher preparedness (10-12). In Delta State, local studies indicate AI improves engagement and lesson planning (13-15), yet widespread adoption is hindered by persistent power, internet and institutional deficits (16). This infrastructural disconnect is particularly severe between urban centers (e.g., Asaba, Warri) and rural/riverine areas (17). Deploying high-bandwidth, cloud-native global AI models without structural adjustments risks widening this digital divide, leaving rural learners technologically excluded and disadvantaged in national examinations like

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WAEC/NECO (18, 19). Ultimately, sustainable AI integration depends on key pillars: teacher readiness (13, 20), infrastructural capacity (16) and ethical awareness regarding algorithmic bias (2) as shown in Table 1. Rather than treating

digital adoption as a one-off procurement project, educational systems must ensure operational durability and contextual adaptation to bridge global technological potential with local realities (2, 16, 21, 22).

Table 1: The Global AI Standard and Nigerian Local Reality Comparism

Axis of Evaluation	Global AI Standard	Nigerian Local Reality	Contextual Friction
Connectivity & Power	Cloud-native, real-time data streaming; 24/7 power	Intermittent grid access, high cost of mobile data, non-uniform coverage	High latency or total service interruption during live classroom sessions
Hardware Access	1:1 student-to-laptop/tablet ratios in classrooms	Shared family mobile devices, low-spec smartphones, crowded computer labs	Complex desktop applications and GPU-heavy tools fail to render
Curricular Alignment	Western-centric datasets, standardized international curricula	WAEC, NECO and JAMB-aligned national curricula; local linguistic diversity	Out-of-the-box global AI models lack local syllabus alignment and regional context
Teacher Support	High digital literacy; AI as a teaching co-pilot	Varying levels of teacher digital literacy; large student-to-teacher ratios	Overwhelming workload without adequate technical onboarding or training

Global meta-analyses show AI transforms STEM education while threatening a North–South gap (2). East Asian studies show academic gains and algorithmic risks (6). In Sub-Saharan Africa (South Africa, Kenya, Ghana, Ethiopia), AI improves learning (23, 24), but benefits favor elite urban schools due to infrastructure, cost, readiness and ethical challenges (16, 23-25). Despite high awareness (15, 26), AI classroom integration in Nigeria remains embryonic (12, 15, 27). Usage is primarily administrative (11, 14) due to low competence (26), ethical issues (27) and infrastructural deficits (13). Systemic policy and training are essential for reform (16, 24, 28), while AI's impact on Delta State learning outcomes remains unstudied (14).

Theoretical Review

The Study is Hinged on Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), created and asserts that two primary cognitive attitudes influence the adoption of technology: Perceived Usefulness (PU), which is the conviction that tools such as ChatGPT or adaptive tutoring improve performance and Perceived Ease of Use (PEOU), which is the conviction that using the tool will be simple (29). TAM models how instructors and students develop attitudes toward AI tools and evaluates each person's psychological preparedness in AI in Education (AIED). Additionally, it describes how a teacher's initial

level of ICT proficiency affects PEOU, which in turn determines whether or not they plan to incorporate AI into their regular lessons (e.g., determining if a Delta State teacher considers an AI tool as time-saving or unnecessarily complex). TAM helps assess whether Delta State teachers and students see global AI tools as solutions to overcrowded classrooms.

Statement of the Problem

AI adoption in Nigerian secondary schools—particularly in Delta State—remains minimal and symbolic due to systemic issues like weak funding, poor policy and severe urban-rural infrastructure gaps. Furthermore, a lack of empirical research on student outcomes and ethical considerations prevents policymakers from creating effective, context-specific AI education strategies. This study examines AI trends, challenges and prospects in education.

Specifically, the study seeks to:

- Investigate global trends and challenges in the integration of Artificial Intelligence in education and extract implications for developing contexts.
- Assess the current level of AI adoption, teacher readiness and infrastructural capacity in Delta State secondary schools.
- Examine the relationship between AI utilization and students' learning outcomes, particularly cognitive development and academic achievement.

To guide the inquiry, the following research questions were formulated:

- a) What are the global trends and challenges associated with the integration of Artificial Intelligence in education?
- b) What is the current state of AI adoption, teacher readiness and infrastructural support in secondary schools within Delta State, Nigeria?
- c) How does the use of Artificial Intelligence relate to students' cognitive and academic performance in Delta State secondary schools?

The following null hypotheses were tested at 0.05 level of significance.:

- a) There is no significant difference between global AI-in-education trends and those observed in Delta State secondary schools.
- b) Teacher readiness and infrastructural adequacy do not significantly predict the level of AI adoption in Delta State secondary schools.
- c) There is no significant relationship between AI utilization and students' academic performance and cognitive development in Delta State.

Methodology

This study adopted an exploratory sequential mixed-methods design that integrated quantitative and qualitative approaches to achieve a comprehensive understanding of the trends, challenges and future prospects of Artificial Intelligence (AI) in education within Delta State, Nigeria. An exploratory sequential mixed-methods design is a two-phase research approach where you start by gathering qualitative data to explore an unknown or under-researched topic and then use those findings to build and execute a quantitative phase. The choice of this design was anchored on the need to triangulate statistical evidence with human experience, consistent with framework (30), which emphasizes the complementarity of quantitative precision and qualitative depth in educational technology research. The study population comprised all teachers and principals in public secondary schools in Delta State. 497 public secondary schools, distributed across the three senatorial districts—Delta North [161], Delta Central [167] and Delta South [169]. GPS Coordinate for the research site is 5.5273° N, 6.1784° E. Public secondary schools were chosen because they represent the institutional foundation for AI policy implementation in the state's educational system. A

stratified random sampling technique was employed to ensure balanced representation across the three senatorial districts of Delta State—North, Central and South. This method was suitable because the population of teachers and principals in public secondary schools is heterogeneous, varying by geographical location, infrastructural access and institutional characteristics. Stratification therefore enhanced representativeness and minimized sampling bias, thereby improving the external validity of the study. From the total population of 497 public secondary schools, 50 schools (approximately 10%) were selected. Within the selected schools, 500 respondents (450 teachers and 50 administrators) were initially targeted for the quantitative phase, while 20 participants (15 teachers and 5 principals) were purposively chosen for qualitative interviews. After data collection, 482 valid responses were retrieved, representing a response rate of 96.4%, which exceeds the recommended 70% benchmark for survey reliability in educational research. The high response rate enhanced the accuracy of statistical estimates and reduced non-response bias. The quantitative sample ensured statistical generalization, while the qualitative sub-sample offered deeper contextual insights, achieving methodological triangulation that strengthened both the validity and interpretive depth of the findings. Data collection involved two primary instruments: a structured questionnaire titled Artificial Intelligence in Education Adoption Scale (AIEAS) and a semi-structured interview guide. The questionnaire was customized to reflect the realities of Nigeria's secondary education system. The instrument consisted of five sections: demographic information, AI integration, teacher readiness, infrastructural adequacy, ethical awareness and perceived educational outcomes. Responses were rated on a five-point Likert scale ranging from Strongly Disagree [1] to Strongly Agree [5]. The semi-structured interview guide explored participants' lived experiences regarding infrastructure, training, ethical use and institutional policy on AI. Each interview lasted between 25 and 35 minutes, conducted either in person or online depending on accessibility. The qualitative component provided rich, descriptive insight into the numerical trends revealed by the quantitative data.

Instrument validity was ensured through expert review. Three specialists—two in educational technology and one in measurement and evaluation—from the Federal University of Petroleum Resources, Effurun, examined the questionnaire for clarity, structure and alignment with the study's constructs. Their feedback led to rephrasing ambiguous items and removing redundant statements. To test reliability, a pilot study was carried out among 50 teachers from five schools excluded from the main sample. Using Cronbach's Alpha, reliability coefficients were computed as follows: AI integration [0.88], teacher readiness [0.86], infrastructure [0.84] and educational outcomes [0.82], yielding an overall reliability of $\alpha = 0.85$, considered highly acceptable. Data collection occurred in two phases. During the quantitative phase, the researcher and three trained assistants distributed the AIEAS questionnaires across sampled schools after obtaining official clearance from the Ministry of Education and school heads. Out of 500 distributed questionnaires, 482 were retrieved, giving a response rate of 96.4%. In the qualitative phase, 20 participants were interviewed using open-ended questions to probe contextual factors influencing AI adoption. Responses were recorded (with consent), transcribed verbatim and supplemented with field notes for interpretive accuracy. Data were analyzed using both statistical and thematic techniques. Quantitative data were processed using SPSS version 27. Descriptive statistics—means, standard deviations and frequencies—summarized the data, while inferential statistics tested the hypotheses at a 0.05 significance level. Specifically:

- a) Independent t-tests examined differences between global and local AI integration trends (Hypothesis 1).

- b) Multiple regression analysis tested whether teacher readiness and infrastructure predicted AI adoption (Hypothesis 2).

- c) Pearson correlation analysis explored relationships between AI utilization and student academic performance (Hypothesis 3).

For the qualitative data, thematic analysis followed (31) six-step framework; familiarization, coding, theme development, review, definition and reporting. Themes were cross-referenced with quantitative findings to identify convergences and divergences. Strict ethical protocols were maintained throughout the study. All participants signed informed consent forms. Confidentiality was protected through coded identifiers and encrypted data storage. Participants were informed of their right to withdraw at any point without repercussion. Recorded interviews were permanently deleted after transcription to ensure data security and compliance with ethical standards recommended by the American Educational Research Association (32). This robust design approach thus enabled the study to systematically assess both the measurable and experiential dimensions of AI in education—linking global trends to local realities in Delta State.

Results

RQ1: What are the global trends and challenges associated with the integration of Artificial Intelligence in education?

To address this question, data were collected on teachers' awareness, understanding and accessibility to Artificial Intelligence (AI) tools in secondary schools in Delta State. The data were analyzed using descriptive statistics (mean and standard deviation).

Table 2: Mean Scores and Standard Deviation of Respondents

Items	Mean	Standard Deviation	Interpretation
Awareness of AI concepts	4.31	0.64	High
Understanding of AI applications in teaching	4.10	0.72	High
Access to AI-based Instructional tools	2.46	0.89	Low
Frequency of AI use in classroom	2.38	0.84	Low
Institutional encouragement for AI use	2.75	0.92	Moderate
Aggregate Mean	3.20	0.80	Moderate

Table 2 shows that respondents demonstrated high awareness ($M = 4.31$) and understanding ($M = 4.10$) of AI concepts but low access ($M = 2.46$)

and usage ($M = 2.38$) of AI technologies. The aggregate mean of 3.20 suggests that while teachers are conceptually aware of AI, its practical

integration remains limited. The result implies that the Delta State education system is at the “awareness phase” of AI adoption, with teachers recognizing AI’s potential but constrained by inadequate infrastructure and training. To test whether Delta State’s AI integration significantly differs from global benchmarks, the following hypothesis was examined.

H01

There is no significant difference between global AI-in-education trends and those observed in Delta

State secondary schools. A one-sample t-test was used to compare the global mean level of AI integration ($M = 3.90$), derived from UNESCO’s global education index — with the mean level in Delta State ($M = 3.200$). A one-sample t-test was conducted to determine whether the mean AI Integration Index in secondary schools in Delta State differs significantly from the benchmark Global Mean as shown in the Table 3.

Table 3: One-Sample t-Test Comparing Global and Delta State AI Integration Levels

Variable	Test value (Global Mean)	N	Mean (Delta State)	SD	t- value	df	Sig. (2- tailed)
AI Integration index	3.90	482	3.20	0.80	14.37	481	0.001*

Note: N = Sample Size, SD = Standard Deviation, df = Degree of Freedom, Sig = Significance level. The * means statistically significant.

According to the null hypothesis (H0), there is no significant difference between global AI-in-education trends and those observed in Delta State secondary schools. The null hypothesis is rejected since the computed p-value, $p=0.001$ is smaller than the significance level ($\alpha=0.05$). The degree of AI integration in Delta State differs significantly from worldwide trends $t[481] = 14.37$, $p = 0.001$. Delta State’s sample mean = 3.20, SD = 0.80 is significantly below the global benchmark mean [3.90]. The average disparity is -0.70. Cohen’s d for a one-sample test is calculated as $d = -0.875$. A high

effect size is indicated by a Cohen’s $d = 0.875$. This indicates that Delta State’s lack of AI integration in comparison to worldwide averages is a significant, real disadvantage rather than merely a statistical anomaly.

RQ2:What is the current state of AI adoption, teacher readiness and infrastructural support in secondary schools within Delta State, Nigeria?

To answer this research question, descriptive statistics were used to analyze teachers’ levels of readiness for AI integration and the adequacy of infrastructural support in their schools.

Table 4: Mean Scores and Standard Deviation of Respondents

Item	Mean	Standard Deviation	Interpretation
Teachers’ digital literacy	3.94	0.77	High
Confidence in using AI tools	3.61	0.81	Moderate
Institutional technical support	2.73	0.95	Low
Availability of reliable power supply	2.58	0.91	Low
Access to stable internet connectivity	2.49	0.88	Low
Availability of AI software in schools	2.66	0.83	Low
Aggregate Mean	3.00	0.86	Moderate

The data in Table 4 reveal that teachers in Delta State possess relatively high digital literacy ($M = 3.94$) and confidence in basic technology use ($M = 3.61$), but infrastructural factors such as power supply ($M = 2.58$), internet access ($M = 2.49$) and institutional support ($M = 2.73$) remain critically low. The overall mean of 3.00 indicates moderate readiness and inadequate infrastructure. This shows that teachers have the skills and willingness

to adopt AI but are constrained by infrastructural and policy barriers.

H02

Teacher readiness and infrastructural adequacy do not significantly predict the level of AI adoption in Delta State secondary schools. To test this hypothesis, a multiple regression analysis was conducted to determine how well teacher readiness and infrastructure predict AI adoption.

Table 5: Multiple Regression Analysis Predicting AI Adoption from Teacher Readiness and Infrastructure (N = 482)

Predictor	B	SE	β	t-value	p-value
Teacher Readiness	0.43	0.06	0.43*	7.17	0.001
Infrastructure	0.39	0.05	0.39*	7.80	0.001

Note: β = Standardized Beta, B = Unstandardized Coefficient, SE = Standard Error, t-value = t-Statistic, p-value = Significance Level.

*Approximate standardized value assuming standardized metrics

As seen in Table 5, the level of AI adoption in Delta State secondary schools rises by 0.43 units for every unit increase in Teacher Readiness (B=0.43, SE=0.06, t=7.17, p<0.001) when infrastructure adequacy is held constant. Teacher preparedness has a strong, statistically significant direct impact on the adoption of AI because p<0.001. Infrastructural Adequacy (B=0.39, SE=0.05, t=7.80, p<0.001): With teacher readiness held constant, the level of AI adoption rises by 0.39 units for every unit increase in Infrastructural Adequacy.

Infrastructure accessibility is a statistically significant foundational determinant of AI adoption, with p<0.001. Teacher readiness (t=7.17, p<0.001) and infrastructure (t=7.80, p<0.001) are both positive and statistically significant determinants of AI adoption in Delta State

secondary schools, according to the multiple regression analysis. The null hypothesis which states that Teacher readiness and infrastructural adequacy do not significantly predict the level of AI adoption in Delta State secondary schools is therefore rejected since it is significant.

RQ3

How does the use of Artificial Intelligence relate to students' cognitive and academic performance in Delta State secondary schools?

This research question was designed to determine how teachers perceive the influence of AI tools on students' learning outcomes — including cognitive development, creativity and academic performance. Descriptive statistics were computed to summarize teachers' responses.

Table 6: Mean Score and Standard Deviation of Respondents

Item	Mean	Standard Deviation	Interpretation
AI improves students' problem-solving skills	3.97	0.74	High
AI enhances creativity and engagement	4.02	0.69	High
AI facilitates personalized learning	3.88	0.77	High
AI improves students' academic achievement	3.73	0.83	Moderate
AI supports timely feedback and assessment	3.84	0.79	High
Aggregate Mean	3.89	0.76	High

Table 6 indicates that teachers generally perceive AI as having a positive effect on students' cognitive and academic development (aggregate M = 3.89). The highest-rated items were creativity and engagement (M = 4.02) and problem-solving skills (M = 3.97) showing that AI tools are viewed as effective for enhancing higher-order thinking skills. However, the slightly lower mean for "improves academic achievement" (M = 3.73) suggests that while teachers recognize AI's instructional benefits, they are cautious about attributing direct academic improvement solely to

AI tools. Overall, the data show that teachers perceive AI as an effective instructional enhancer with both cognitive and motivational benefits for students.

H03

There is no significant relationship between AI utilization and students' academic performance and cognitive development in Delta State. To test this hypothesis, a Pearson Product Moment Correlation (PPMC) analysis was conducted to determine the relationship between AI utilization and students' learning outcomes.

Table 7: Correlation between AI Utilization and Student Learning Outcomes (N = 482)

Variables	Mean	SD	r	P-value	Decision
AI Utilization	3.20	0.80	0.72	0.001*	Significant
Student Learning Outcomes	3.89	0.76			

Note: SD = Standard Deviation, r = Pearson Correlation Coefficient, P-Value = Significance Level. The * denotes a statistically significant relationship.

As shown in Table 7, the Pearson correlation coefficient ($r = 0.72$, $p = 0.001$) indicates a strong positive relationship between AI utilization and student learning outcomes. This means that higher levels of AI use in teaching are associated with greater student engagement, creativity and performance. The result is statistically significant at $p < 0.05$, leading to the rejection of Hypothesis Three. This implies that effective adoption of AI tools enhances both cognitive development and academic achievement among students in Delta State.

Discussion

The findings of this study provide an integrated understanding of the global and local dimensions of Artificial Intelligence (AI) adoption in education, particularly in the context of Delta State secondary schools. The discussion interprets these results in relation to earlier studies and theoretical perspectives presented in the review of related literature. The results revealed that teachers in Delta State demonstrated high awareness of AI concepts ($M = 4.31$) and applications ($M = 4.10$) but reported low access and usage of AI-based instructional tools ($M = 2.46$). This discrepancy indicates that AI integration in the state is still in its early phase—characterized by awareness without sufficient implementation. The one-sample t-test confirmed a statistically significant difference between global AI integration levels ($M = 3.90$) and Delta State's mean ($M = 3.20$), implying that local adoption lags far behind international standards.

These findings align with other study (9), which observed that while global education systems—particularly in the United States, China and Finland are leveraging AI to personalize and improve learning outcomes, most developing regions remain at a foundational stage of digital readiness. Similarly, global AI adoption has enhanced learning outcomes, especially in STEM fields, demonstrating how technological access directly correlates with educational efficiency (1). However, the significant difference between global and Delta State AI levels reflects the structural barriers noted in the literature, including weak infrastructure and insufficient policy support (7, 32). This pattern is also consistent with past research (5), who found that high-level policy support and government-funded AI programs in

China significantly improved students' mathematics performance, unlike contexts with poor infrastructure and limited teacher training. Consequently, the present study corroborates earlier assertions that awareness alone does not translate into meaningful adoption unless accompanied by institutional readiness and sustained investment.

The statistical results show that when it comes to implementing and integrating artificial intelligence tools into classroom instruction and school administration, Delta State secondary schools fall well short of global criteria. While generative AI, adaptive learning software and intelligent tutoring systems are quickly being incorporated into conventional curricula by worldwide educational institutions, especially in high-income areas, Delta State secondary schools have structural local obstacles. This discrepancy between local realities ($\text{mean} = 3.20$) and global targets ($\mu = 3.90$) can be attributed to a number of fundamental issues raised in recent empirical research: Hardware access, fast internet and steady electricity are necessary for integrating AI. Lack of operational ICT labs and unstable power supplies are common problems for schools in underdeveloped regions. Teachers are frequently untrained in Technological Pedagogical Content Knowledge (TPACK) specific to contemporary AI tools. Schools lack established channels to obtain and govern instructional AI technologies due to the lack of clear state-level regulatory frameworks and specialized financial sources.

The second research question examined teachers' readiness and infrastructural support in Delta State. Findings showed relatively high teacher digital literacy ($M = 3.94$) but critically low access to infrastructure such as power ($M = 2.58$) and internet connectivity ($M = 2.49$). The multiple regression analysis revealed that both teacher readiness and infrastructure significantly predicted AI adoption with teacher readiness slightly stronger than infrastructure ($\beta = 0.43$). This suggests that while structural limitations constrain integration, teachers' competence and confidence remain decisive for adoption. These findings reinforce the Technology Acceptance Model (29) and TPACK framework (33) that underpin this study. According to these models, technological adoption depends not only on environmental enablers but also on teachers'

perceptions of usefulness, ease of use and pedagogical alignment. The strong predictive power of teacher readiness observed here validates these theoretical assumptions.

Empirically, the present findings are consistent with those of another research (13), who found that ICT-trained teachers were twice as likely to adopt AI tools as untrained peers. Likewise, low technical competence among teachers remains a key barrier to AI integration in Nigerian secondary schools (12). The infrastructural constraints identified in this study—particularly erratic electricity and limited internet access—also mirror the concerns raised by other studies in Ghana (16) and in South Africa (23), where AI adoption was found to be more successful in urban, resource-rich schools. Overall, this study confirms that teacher readiness and infrastructure jointly determine AI integration. However, the relatively higher influence of readiness underscores the importance of continuous professional development programs and policy-driven digital literacy training. It further implies that empowering teachers intellectually may partially offset infrastructural deficiencies in the short term. The third research question explored the relationship between AI utilization and students' cognitive and academic outcomes. Descriptive analysis indicated that teachers perceived AI as having a high impact on creativity ($M = 4.02$), problem-solving ($M = 3.97$) and personalized learning ($M = 3.88$), though they were more cautious about its direct influence on academic achievement ($M = 3.73$). The correlation analysis ($r = 0.72$, $p = 0.001$) confirmed a strong positive relationship between AI utilization and student learning outcomes, suggesting that effective use of AI tools significantly enhances engagement, creativity and performance. These findings are consistent with the global meta-analysis (2), which reported that 81% of AI interventions improved learning outcomes, particularly in STEM. Likewise, in Kenya found a 21% increase in student test scores following AI-assisted instruction (24), while improved writing skills was observed among Ethiopian students exposed to AI-supported platforms (25). The alignment between the present results and these studies validates AI's pedagogical benefits even in resource-constrained environments when appropriately applied. At the national level, the results align with the

observations of previous study (14), who noted that AI tools improved administrative efficiency and teacher planning in Delta State but had not yet been systematically linked to student performance. By empirically demonstrating this linkage, the current study fills a critical gap in Nigerian literature. Moreover, the results support previous study (11), who emphasized that AI enhances efficiency and academic productivity where teachers are adequately trained.

The relatively moderate mean for academic achievement ($M = 3.73$) may reflect teachers' awareness of contextual limitations such as unstable internet, limited student exposure to AI tools and inconsistent electricity—all factors that mediate learning gains. Nonetheless, the overall strong positive correlation underscores AI's potential to stimulate higher-order thinking, self-paced learning and cognitive engagement when effectively deployed. Collectively, the findings position Delta State within the broader narrative of developing countries striving to bridge the global digital divide. The results confirm earlier theoretical propositions that technological integration is a multidimensional process shaped by human, infrastructural and institutional factors. The significant influence of teacher readiness and infrastructure supports the TPACK framework (30) and the TAM model (29), while the strong relationship between AI use and learning outcomes reflects the perceived usefulness construct central to TAM. From a policy perspective, these findings highlight the urgent need for investment in digital infrastructure—particularly internet connectivity and electricity—to sustain AI adoption. Moreover, ongoing teacher training and ethical literacy programs are vital to ensure that AI applications promote fairness, privacy and inclusivity as emphasized by past study (2). The study's integration of global and local evidence thus provides a contextual framework for scaling AI initiatives in Delta State and similar developing regions.

The rejection of the null hypothesis in Table 5 demonstrates that both human capability (Teacher Readiness) and physical facilities (Infrastructural Adequacy) play a significant role in the integration of contemporary educational innovations, particularly Artificial Intelligence, in Delta State secondary schools. Teachers' digital literacy, psychological preparedness, self-efficacy and

pedagogical confidence are crucial preconditions for using generative AI technologies (such as automated grading, adaptive learning systems and lesson planners), according to the empirical coefficient ($B=0.43$, $p<0.001$). Even when state-of-the-art AI technology are made available, adoption is severely hampered by a lack of teacher training, technophobia, or concerns about role displacement. As a result, creating focused professional development programs in digital literacy and AI pedagogy greatly speeds up Delta State educators' adoption of technology. Software-driven tools like AI cannot operate in an infrastructural vacuum, as demonstrated by the significant regression path for Infrastructure ($B=0.39$, $p<0.001$). The physical link to digital transformation in secondary schools throughout Delta State is provided by reliable energy, fast internet, working computer gear and safe server capacity. Digital education plans often stall before they are implemented in classrooms due to deficiencies in fundamental technology and power grids. Stakeholders must put in place a dual-track strategic plan that funds ongoing, useful AI capacity building for secondary school teachers while also upgrading physical ICT infrastructure in order to enable sustainable AI adoption.

Conclusion

This study examined global trends and local realities of Artificial Intelligence (AI) integration in education, focusing on secondary schools in Delta State, Nigeria. Findings revealed that although teachers demonstrated high awareness and positive perceptions of AI, actual classroom application remains low due to infrastructural and institutional constraints. Teacher readiness and infrastructure significantly predicted AI adoption, confirming that both human and structural capacities are critical enablers of technological transformation. Moreover, a strong positive relationship ($r = 0.72$, $p < 0.05$) was found between AI utilization and students' learning outcomes, underscoring AI's potential to enhance creativity, engagement and academic performance. The study concludes that Delta State is still at the awareness stage of AI integration, requiring sustained investment in infrastructure, teacher training and ethical policy frameworks. Strengthening these areas will align the state's educational system with

global standards and promote equitable, technology-driven learning across Nigeria.

Based on the findings and aligned with global best practices, the following recommendations are proposed:

- a) **Teacher Capacity Development:** Regular professional training programs should be institutionalized to strengthen teachers' AI competencies and digital pedagogical skills. Teachers' competence remains the most influential determinant of AI adoption.
- b) **Infrastructure Investment:** The government and education stakeholders should prioritize the provision of stable electricity, reliable internet connectivity and access to AI-enabled educational software.
- c) **Policy and Curriculum Integration:** The Delta State Ministry of Education should develop a comprehensive AI-in-Education Policy
- d) **Framework, harmonized with UNESCO's global AI education strategy:** The framework should mandate ethical AI literacy, ensure data privacy compliance and promote inclusive access for both urban and rural schools.
- e) **Rural and Development (R&D) Incentives:** Academic institutions should be encouraged to establish AI research clusters and collaborate with technology firms to localize AI tools for Nigerian learning contexts. This would ensure context-specific innovation rather than imported digital solutions that may not fit local realities.
- f) **Ethical Governance:** Ethical guidelines should accompany every AI deployment in schools to prevent algorithmic bias, protect student data and promote equity.
- g) **Monitoring and Evaluation Mechanisms:** A centralized digital monitoring system should be developed by the Ministry of Education to periodically assess AI usage, teacher readiness and student performance. Such continuous evaluation will help policymakers adjust implementation strategies based on empirical evidence.

Despite its methodological rigor, this study is not without limitations. First, the study focused exclusively on public secondary schools in Delta State, which, although representative of the state's educational structure, limits the generalizability of findings to private institutions or tertiary contexts. Future research should therefore include a

broader sample encompassing diverse school types and geopolitical zones across Nigeria for comparative validation. Second, data were primarily collected through self-reported questionnaires and interviews, which are subject to potential social desirability bias. Although triangulation with quantitative and qualitative data minimized this effect, observational or experimental designs could provide stronger causal inference in future investigations.

Finally, the technological and infrastructural conditions in Delta State during the period of study may have influenced teachers' responses. Given the rapid evolution of digital tools, longitudinal studies are recommended to track changes in AI adoption and learning outcomes over time.

Abbreviations

None.

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Author Contributions

Omonefe Jemilatu Moses-Promise: Original Draft Preparation, Conceptualization, Methodology, Software, Validation, Aruoture Raphael Ayoro: Data Curation, Writing- Original Draft Preparation, Omokaro Adams Ekwevugbe: Visualization, Validation, Investigation, Odiri Ejakpomeghwe Onoshakpokaiye: Supervision, Reviewing and Editing.

Conflict of Interest

All authors declares that they have no conflicts of interest.

Data Availability

The data that support the findings of this study are obtainable from the corresponding author on reasonable request

Declaration of Artificial Intelligence (AI) Assistance

During the preparation of this manuscript, the authors utilized generative artificial intelligence (AI) tools exclusively to enhance readability, grammar and structural flow. The AI tools were not involved in data collection, analysis, interpretation, or drawing study conclusions. All scientific contributions, analyses and interpreta-

tions are the sole work of the authors, who assume full accountability for the content and integrity of this manuscript

Ethics Approval

Before the study was carried out, consent was obtained from each respondent.

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