

The Role of Artificial Intelligence-Powered Learning Assistants in Enhancing Computer Science Education in North-West Nigerian Universities

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Abstract

This study examines the challenges and strategies for implementing AI learning assistants in computer science education within six universities in North-West Nigeria. The study adopted a mixed-methods survey to examine 387 participants and found that infrastructural challenges, such as insufficient internet connectivity and power supply, were identified as the most dominant barriers to implementing AI learning assistants, thereby differentiating this study from similar ones conducted in well-resourced environments where concerns about academic integrity were prominent. Other barriers identified include cost, access to devices, and insufficient expertise. The study also found that there is a significant difference in perceived benefits among different stakeholders ($\chi^2 = 31.278, p = .008$). The study proposes four key strategies for optimization, which include hybrid implementation models, contextualized pedagogical frameworks, leadership commitment in institutions, and localization for Nigerian languages and contexts. The study's original contribution is that it focuses on African institutional experiences in the global discourse on AI in education, revealing how the second-order digital divide influences technology uptake in constrained environments for higher learning. The study's findings show that basic infrastructure investments should be made before or at the same time as AI to avoid further inequalities in education.

Keywords: Artificial intelligence in education, AI-powered learning assistants, computer science education, resource-constrained contexts, digital divide, Nigerian Tertiary education, implementation challenges, educational technology, Global, optimization strategies

1. Introduction

The rapid advancement of Artificial Intelligence (AI) technologies has triggered significant changes in various fields. Education has become one of the most important fields in terms of AI-based innovation (Nuzli et al,2023; Guan et al., 2020). AI-based learning assistants are one of the most important innovations in the field of education in recent times. AI-based learning assistants are intelligent systems that have the ability to provide personalized learning and immediate feedback. This innovation can be considered one of the most important innovations in the field of education in recent times. AI-based learning assistants have the potential to solve some of the important problems in the field of education. One of the important problems in the field of education is the availability of instructors.

In particular, computer science education is likely to reap substantial benefits from the integration of AI. Education in programming is fundamentally characterized by complex problem-solving and learning abstract concepts related to computing, which often demands extensive practice and individualized support for learners (Wang, & Hwang, 2017; Rakhimboeva, 2025). However, traditional face-to-face learning is often insufficient to provide learners with extensive and individualized support, especially due to large student-instructor ratios and contact time limitations. AI-powered learning assistants can provide learners with 24/7 support and instant feedback on submitted programming codes (Natalapati et al., 2024; Ananda et al., 2025).

Nigerian tertiary education has its own set of challenges to contend with in its integration of AI-powered learning technologies. For instance, according Isma'il et al., (2023) reported that, there has been an increase of over 40% in the number of enrolled students in Nigerian universities from 2015 to 2023 through the National Universities Commission 2023. This has resulted in computer science classes that often have over 100 students to contend with. According to the National Bureau of Statistics 2023, less than 35% of Nigerian universities have access to broadband connectivity (Asaju & Ashepo, 2025). The World Bank 2024 has identified that less than 60% electricity access in the North-West geopolitical zone is one of the major infrastructure challenges facing Nigeria. This is a very different technology environment from that of the Global North that is mostly used in research on AI in education.

In spite of this increasing global embrace of AI learning tools, their deployment in African tertiary learning environments characterized by scarce resources, especially in North West Nigeria, is critically understudied (Birma et al., 2025; Sambo-Magaji et al., 2025). Available optimisation strategies and frameworks often rely on the assumption of stable connectivity and well-resourced support structures, which is not the case in Nigerian universities (Adeniranye, 2026). The present study directly responds to this critical gap.

Research Objectives

This study is guided by the following objectives:

- i. To identify key challenges and limitations associated with integrating AI-driven learning support tools into computer science education in North-West Nigerian universities.
- ii. To propose evidence-based strategies for optimizing AI-powered learning assistants to enhance student academic performance in resource-constrained contexts.

Research Questions

The study addresses the following research questions:

- i. What key challenges and limitations do students and educators encounter when integrating AI-driven learning support tools into computer science education in North-West Nigerian universities?
- ii. What strategies can be implemented to optimize AI-powered learning assistants for improved student academic performance and personalized learning experiences in resource-constrained contexts?

The remainder of this paper is organized as follows: Section 2 reviews relevant literature. Section 3 presents the research methodology. Section 4 reports findings and discusses implications. Section 5 concludes with recommendations and directions for future research.

2. Related Works

This section synthesizes the research on AI in education, grouped around four key areas: the theoretical foundations, the application of AI in computer science education, the challenges of implementation in resource-constrained environments, and the cultural and linguistic aspects. The section will also discuss the applicability or lack thereof of the frameworks to the Nigerian setting, culminating in the articulation of the research gap. The cognitive base of AI in education can be traced back to intelligent tutoring systems (ITS) developed in the 1970s, which focused on mimicking human tutoring by developing models based on domains, students, pedagogy, and interfaces (Latif et al., 2026). Although these early systems showed promising results in terms of student learning outcomes in mathematics and physics, these systems were limited by their knowledge representations and high authoring costs (Anderson et al., 2018; Worku et al., 2026). However, the new crop of AI-based assistants using transformers like GPT and BERT overcome these limitations by using natural language processing capabilities (Larson et al., 2025; Nerella et al., 2024).

There are two theoretical frameworks that are particularly relevant to this study. First is Vygotsky's (1978) concept of Zone of Proximal Development (ZPD), where AI is considered to be a digital scaffold that helps facilitate the transition of learners from assisted to independent performance, where the role of the "more knowledgeable other" is performed by the AI system (Hamid, & Abbas, 2025; Lee, & Palmer, 2026). Second is the Digital Divide Theory (Dinker, 2024), which reminds us that unequal access to technology can lead to unequal opportunities for individuals to access and benefit from the potential of AI. In Nigeria, this is manifested as "a second-order digital divide," where despite having access to devices to use AI tools, unequal access to better quality connections and skills can be limiting factors. The pedagogical potential of the use of AI learning assistants in programming education is substantial, especially for novice programmers, as shown in the works of Philbin (2023) and Alanazi et al. (2026). The research findings indicate that the use of GitHub Copilot, ChatGPT, and other similar tools can improve the speed of task completion and reduce the level of psychological barrier to seeking help (Eshraghian et al., 2025; Cavalcante, 2025). However, the findings are always mixed, indicating that while novice programmers can complete tasks faster, the results of the use of AI tools are not necessarily associated with better conceptual understanding, as some students become confused about the actual workings of the solutions provided by the tools (El Fathi et al., 2025). The use of AI tools as a tutoring system, which incorporates specific pedagogical strategies, has shown more positive results than the use of unguided tools (Lin et al., 2023). The concerns about academic integrity and overreliance have prompted some to adopt a very restrictive approach, considering the use of unsanctioned AI as a form of academic misconduct. However, some teachers have argued for a more pedagogy-centered approach, which re-engineers the curriculum to include more complex skills like problem decomposition, debugging strategies, and code reviews, which are more difficult to outsource to AI (Borenstein & Howard, 2020). Most importantly, the majority of the research has come from well-funded universities in North America and Europe, which is a concern for Nigerian universities, as the problem is more of access than overreliance. The influence of infrastructural limitations, largely not encountered in studies conducted in the Global North, is profound for the implementation of AI education tools in Sub-Saharan Africa. For instance, access to high-speed internet, which is vital for cloud-based AI tools, is often lacking in Nigerian universities due to persistent outages and lack of bandwidth (Oreoluwa, 2024; Chinedu et al., 2025). Outdated computing facilities and lack of laboratory space further contribute to this limitation, prompting mobile-first

strategies as a partial alternative (Evanick Ed, 2024). In this regard, the economic factors add yet another dimension of complexity in the adoption process. For example, although AI platforms are often provided for free, the functionality and usage limitations make them unsuitable for academic purposes, and the cost of the premium subscription in foreign currency is beyond the financial capacity of most Nigerian universities (Adediran, 2024; Luwoye, 2024). Human capacity limitations add yet another dimension of structural factors in the adoption process. For example, opportunities for professional development in AI pedagogy are limited, and human factors, including attitude, are critical in the adoption process in Nigeria and are different from the literature in the Global North, which is mainly focused on pedagogy and ethical concerns rather than structural factors. The current AI learning assistants are mostly in English. This has created a significant barrier in Nigeria, given that there are more than 500 indigenous languages and that most of the students think in their mother tongue (Ugwu, & Ogunremi, 2019; Makinde, 2021). Research has shown that students learn better when they can first engage in learning in their first language before being translated into a second language (Warschauer et al., 2023). This implies that AI learning assistants that can support code-switching will be useful. However, natural language processing for some of the African languages is still in its infancy due to lack of investment in those languages (Hu et al., 2025). In addition to language support, culturally sensitive AI learning content that reflects African epistemology and examples rather than the current dominant Western epistemology will be essential for its effective implementation in Africa (Ofosu-Asare, 2025; Aboderin, 2025). Literature has consistently shown that AI integration frameworks developed for resource-rich institutions cannot be transferred to resource-constrained institutions in Africa without fundamental changes. However, the majority of the studies done have been in institutions in the Global North, leaving significant knowledge gaps in terms of implementation in Nigeria and similar settings (Ezeanolue et al., 2018; Kalbarczyk et al., 2021). In Nigeria in particular, the North-West geopolitical region has significant knowledge gaps in terms of AI learning assistant implementation due to the presence of the most serious infrastructure gaps and highest linguistic diversity in Nigeria. Yet, to the best of knowledge, no published study has been done to examine AI learning assistant implementation in the universities in this region. This study will fill this knowledge gap and make a significant academic contribution to the body of knowledge in terms of digital divide theory in education.

3. Methodology

This study employed a cross-sectional survey research design utilizing a sequential mixed-methods approach, combining quantitative Likert-scale questionnaires with open-ended qualitative items. The cross-sectional design was selected to capture a comprehensive snapshot of AI learning assistant challenges and opportunities across multiple institutions within a defined timeframe (Yousef, 2025). The mixed-methods approach enables triangulation of quantitative patterns with qualitative depth, producing a more complete understanding of implementation dynamics than either approach alone could provide.

Sampling Technique

A multi-stage sampling procedure was employed. In stage one, purposive sampling selected the six universities to ensure diversity across federal and state institutions and across sub-regional geographic clusters. In stage two, stratified random sampling was applied within each institution to ensure

proportional representation of undergraduate students, postgraduate students, academic staff, IT support staff, and administrative personnel. A total of 450 questionnaires were distributed, yielding 387 valid responses (86% response rate), which exceeds the 70% threshold recommended for educational survey research (AlQuraan, 2019).

Data Collection Instruments

A structured questionnaire was developed to assess AI learning assistant adoption, covering: (a) demographic characteristics; (b) implementation challenges rated on a 5-point Likert scale (1 = Not a Challenge to 5 = Major Challenge); (c) perceived learning outcome impacts; (d) current usage patterns; and (e) optimization strategy preferences. Open-ended items invited qualitative elaboration on challenges, benefits, and recommendations. The questionnaire was administered both online (60%) and on paper (40%) to maximize reach across connectivity conditions. Data collection occurred over eight weeks (August–October 2024). Informed consent was obtained from all participants, no personal identifiers were collected, and participation was entirely voluntary.

Validity and Reliability

Content validity was established through expert opinions from five academic and ICT experts, thereby achieving a Content Validity Index (CVI) of 0.89, which is way beyond the recommended 0.80 (Lynn, 1986). Construct validity was established through exploratory factor analysis, which verified the proposed factor structure. High internal consistency reliability was established for all dimensions, including implementation challenges (Cronbach's $\alpha = 0.87$), learning outcomes ($\alpha = 0.84$), and optimization strategies ($\alpha = 0.81$), all being way beyond the recommended 0.70 (Nunnally, 1978). A pilot study involving 45 respondents from a non-participating university reduced completion time from 25 minutes to 18 minutes.

Data Analysis Techniques

For quantitative analysis, statistical software SPSS 28.0 was used to conduct various levels of analysis: descriptive statistics such as mean and standard deviation to describe demographic profiles and challenge rating; χ^2 test to examine associations between categorical variables such as differences in challenge rating by roles of respondents; ANOVA test to examine differences in mean benefit rating among different stakeholder groups; Pearson correlation coefficient to examine associations between two quantitative variables. Significance level was set at 0.05. For missing values, less than 2% of total responses were excluded using listwise deletion. χ^2 test was used to examine associations between categorical variables due to its reliability in dealing with ordinal grouped data. ANOVA test was used to examine differences in mean benefit rating among three independent groups of respondents: students, academic staff, and IT staff. For qualitative analysis of open-ended questions, thematic analysis was used following six phases of analysis by Hemming (2024): data familiarization, initial coding, theme searching, theme review, theme definition and naming, final reporting. Two researchers independently coded the open-ended questions. Inter-rater reliability was measured using Cohen's kappa coefficient; $\kappa = 0.82$. Themes were integrated with quantitative findings using convergent mixed methods approach.

4. Results and Discussion

This section presents the quantitative and qualitative findings of the study, organized around the two research objectives. Pure results are reported here; interpretive discussion follows in Section 5.

Sample Distribution

The 387 valid responses were distributed across six universities with response rates ranging from 78.3% to 97.1% (Table 1). The sample was predominantly composed of students (77.8%: 60.5% undergraduate, 17.3% postgraduate), academic staff (15.0%), IT support staff (4.1%), and administrative staff (3.1%). The gender distribution was 64.3% male ($n = 249$) and 35.7% female ($n = 138$), with chi-square analysis revealing statistically significant variation across institutions ($\chi^2 = 14.67$, $df = 5$, $p = 0.012$). Age distribution was predominantly young: 51.2% aged 18–25 years and 85.3% aged 35 years or below, consistent with the typical profile of Nigerian university Computer Science departments.

Table 1: Distribution of Respondents by University

University	Frequency	Percentage	Response Rate
Ahmadu Bello University, Zaria	87	22.5%	87.0%
Bayero University, Kano	69	17.8%	86.3%
Usmanu Danfodiyo University, Sokoto	60	15.5%	85.7%
Kebbi State Univ. of Sci. & Tech.	47	12.1%	78.3%
Federal University, Birnin Kebbi	56	14.5%	80.0%
Kaduna State University	68	17.6%	97.1%
Total	387	100.0%	86.0%

Note. Response rates calculated against questionnaires distributed per institution.

Key Challenges in AI Implementation

Analysis of implementation challenge ratings revealed a clear hierarchy, with infrastructural barriers dominating over pedagogical and ethical concerns (Table 2). Inadequate internet infrastructure ($M = 4.35$, $SD = 0.78$) and unreliable power supply ($M = 4.28$, $SD = 0.82$) received the highest challenge ratings, both classified as “Major Challenges.” These were followed by a second cluster of resource and capacity barriers: high implementation costs ($M = 4.21$), limited device access ($M = 4.18$), lack of technical expertise ($M = 4.12$), and insufficient training programs ($M = 4.08$). Concerns prominent in Global North literature academic integrity ($M = 3.89$) and data privacy ($M = 3.92$) received comparatively moderate ratings. Chi-square analysis revealed statistically significant variation in challenge perceptions by respondent role ($\chi^2 = 31.278$, $df = 12$, $p = .008$).

Table 2: Implementation Challenges and Barriers to AI Adoption

Challenge	Mean	SD	Challenge Level
Inadequate internet infrastructure	4.35	0.78	Major Challenge
Unreliable power supply	4.28	0.82	Major Challenge
High cost of implementation	4.21	0.89	Major Challenge
Limited access to computers/devices	4.18	0.92	Major Challenge
Lack of technical expertise among staff	4.12	0.87	Major Challenge
Insufficient training programs	4.08	0.91	Major Challenge
Limited institutional support	3.98	0.96	Moderate Challenge
Data privacy and security issues	3.92	1.02	Moderate Challenge
Concerns about academic integrity	3.89	1.05	Moderate Challenge
Resistance to change by faculty	3.76	1.08	Moderate Challenge
Student reluctance to adopt technology	3.62	1.12	Moderate Challenge
Language barriers	3.45	1.18	Minor Challenge

Note. Scale: 1 = Not a Challenge; 2 = Very Minor Challenge; 3 = Minor Challenge; 4 = Moderate Challenge; 5 = Major Challenge. SD = Standard Deviation.

Stakeholder Variation in Perceived Benefits

Table 3 presents mean benefit scores disaggregated by respondent category. IT staff rated personalized learning experiences significantly higher ($M = 4.31$) than academic staff ($M = 3.95$) and students ($M = 4.18$), $F(2, 384) = 2.84$, $p = .039$. No statistically significant differences were observed for 24/7 availability ($p = .191$), instant feedback ($p = .375$), or enhanced debugging assistance ($p = .293$).

Table 3: Mean Benefit Scores by Respondent Category

Benefit	Students	Academic Staff	IT Staff	Significance
Personalized learning experiences	4.18	3.95	4.31	$p = .039^*$
24/7 availability	4.29	4.12	4.25	$p = .191$
Instant feedback	4.22	4.08	4.19	$p = .375$
Enhanced debugging assistance	4.19	4.05	4.13	$p = .293$

Note. * Significant at $p < 0.05$. F-tests from one-way ANOVA with post-hoc Tukey comparisons.

Optimization Strategies Identified

Qualitative thematic analysis ($\mathcal{E}f = 0.82$) identified four principal optimization strategies, which converged closely with quantitative preference data:

- i. Phased hybrid implementation has 38.7% of respondents emphasized the need for offline AI tool functionality and dedicated computer laboratory infrastructure to reduce internet dependency.
- ii. Contextualized pedagogical training has 33.1% emphasized alignment of AI tools with specific programming and algorithms course objectives; 28.7% raised concerns about AI output quality, underscoring the need for critical evaluation training.
- iii. Institutional leadership and policy development of the respondents called for clear Acceptable Use Policies (AUPs) and sustained institutional investment in internet and power infrastructure.
- iv. AI localization has 45.2% expressed demand for AI tools supporting major Nigerian languages, alongside locally contextualized programming examples.

Discussion

The pre-eminence of infrastructural barriers, especially internet connectivity and power supply, in the Nigerian setting can be explained by the fact that the structural realities informing the findings of Global North research on the role of AI in education are absent in the Nigerian setting. While the research in the Global North setting identified academic integrity, pedagogy, and data privacy as the major barriers to the adoption of AI in education (Hasanah et al., 2025), the Nigerian setting faces what van Deursen and Helsper (2015) called the "second-order digital divide" – a situation where the quality of internet connectivity is a major barrier to the adoption of cloud-based technologies like AI, especially in the North-West zone, which, according to the Yakubu et al., (2025), faces the worst situation in the country in terms of unreliable electricity supply, coupled with the lowest rate of internet penetration. The fairly moderate rating of academic integrity concerns ($M = 3.89$) in this study also follows from this line of reasoning. Indeed, if the basic problem is to secure any kind of access to AI tools in the first place, the question of preventing their misuse necessarily takes a secondary place. This result fundamentally reorients the policy agenda from one of restriction to one of enablement and infrastructure investment – and does so in ways that have direct relevance to the sequencing of AI integration in similar settings. When viewed in terms of the digital divide perspective, the results suggest that the implementation of AI can be seen as serving to further entrench existing inequalities. The "second-order digital divide" (van Deursen & Helsper, 2015), referring to the gap in terms of access to more reliable connectivity and more advanced facilities within institutions and for individual students, is evident in the current study. The disparity between IT and academic staff in terms of the benefits of personalized learning ($p = .039$) can also be seen to highlight the second-order divide. In this case, the more proximate relationship that IT staff have to the infrastructure and facilities means that they have more optimistic evaluations of the potential for AI to benefit learning, compared to academic staff who have a more nuanced understanding of the day-to-day barriers to learning. The high level of demand for local language support (45.2% of qualitative study participants) suggests that there is a language dimension to the digital divide, whereby English-centric AI tools place an additional cognitive burden on students whose native language is Hausa, Fulfulde, Kanuri, and other

regional languages. This supports Cross (2022) and Translators without Borders (2022) in arguing that language is not an incidental equity consideration but one that is structural in nature.

Implications for Stakeholders

This subsection discusses the implication of findings to relevant stakeholder

University administrators should realize that infrastructure investment is a prerequisite and not a co-requisite for AI integration. Implementation strategies that start with a computer lab and offline-accessible AI tools will allow for meaningful integration within existing constraints and pave the way for further expansion. An institutional Acceptable Use Policy that recognizes AI's role as a learning aid and not a replacement for actual learning is critical to proactively addressing integrity concerns before a likely increase in available AI tools. It is recommended that national and state-level policy makers should focus on broadband connectivity and power supply to university campuses as part of the foundational infrastructure for education, just like laboratory infrastructure and staffing. The policy framework of Tertiary Education Trust Fund (TETFUND) provides a viable avenue for infrastructure investment; this study recommends that AI readiness be included as part of the criteria for funding assessment. In addition, policy frameworks should be developed to support localization of AI technologies for Nigerian languages, which will necessitate investment in Nigerian NLP research. It is essential for commercial and open-source educational technology developers to consider connectivity constraints as a fundamental requirement rather than an afterthought. This will require them to ensure that their products have offline support, mobile support that is highly accessible and does not require significant bandwidth, and language support for key Nigerian languages. Collaboration with Nigerian universities and computational linguists, as suggested by Arokoyo et al. (2025), and the African Languages Lab (2025), will be vital in developing culturally and linguistically sensitive AI technologies. Participatory approaches to designing educational technologies will be more effective in developing relevant technologies.

5. Conclusion

In this study, the level of integration of AI learning assistants in computer science courses in six North-West Nigerian universities was investigated using 387 participants. The study found that, in all cases, the major hindrances to the implementation of AI learning assistants are infrastructural challenges, including internet connectivity, power supply, implementation costs, and access to devices. This is the major difference between the Nigerian and Global North contexts, which have largely been the focus of the literature. The study also found that there are differences in the perception of the benefits of AI learning assistants at the stakeholder level and that there is strong demand for the implementation of AI learning assistants in offline mode and in local languages. Four optimization strategies are proposed: phased hybrid implementation with offline functionality, pedagogical training, leadership buy-in in the form of infrastructure investment and development of Acceptable Use Policy, and localizing AI in Nigeria. The paper makes a number of original contributions to the research on AI in education. It offers the first empirical evidence of the difficulties of implementing AI learning assistants from the North-West region of Nigeria, which, while suffering from the most critical infrastructural challenges, also offers the greatest linguistic diversity within the country. It also offers the first application of the digital divide theory to the domain of AI in education, highlighting the role

of “second-order digital divide” effects in the access to and perception of the utility of AI tools by different stakeholders, and offers implications for practice for administrators of institutions in similar contexts across sub-Saharan Africa. However, there are some limitations that must be addressed. First is the geographical scope of the study, which is only six universities within one region of Nigeria: the North-West geopolitical zone. This limits its ability to be generalized to other regions within Nigeria that might have different infrastructure and cultural backgrounds. Second is that this study only presents cross-sectional data and is unable to show longitudinal changes in the use of AI and infrastructure. Third is that although this study is targeted at students and is adequate for that purpose because of its 77.8% composition, there is a high chance that other views from senior staff within academia might be overlooked. Fourth is that there is social desirability bias in reporting one's patterns of use of AI.

Future research should address these limitations and extend the evidence base in several directions:

- i. Longitudinal studies tracking AI adoption trajectories over multiple academic years to assess whether infrastructure improvements translate into measurable learning outcome gains.
- ii. Experimental and quasi-experimental designs that compare AI-assisted versus non-AI-assisted learning outcomes in programming courses under different connectivity conditions.
- iii. Investigation of technology acceptance models (e.g., TAM, UTAUT) adapted for resource-constrained African educational contexts, to develop predictive frameworks for AI adoption.
- iv. Research on AI localization for Nigerian languages, including evaluation of existing multilingual models' performance on Nigerian programming education tasks.
- v. Comparative studies across Nigerian geopolitical zones and between Nigeria and other sub-Saharan African countries to identify contextually transferable implementation strategies.

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