

The Role of AI-Powered Assessment Tools in Improving Educational Feedback in Nigeria

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Abstract

Educational systems in Nigeria face a persistent challenge in delivering high-quality, timely, and personalized feedback, due primarily to large class sizes, heavy teacher workloads, and reliance on traditional assessment methods. This study investigates the potential of integrating artificial intelligence (AI)-powered assessment tools to overcome these systemic barriers and improve the quality of educational feedback within the Nigerian secondary school context. Employing a quantitative cross-sectional survey design, data were collected from teachers and students across three geopolitical zones. Statistical analyses, including regression modeling, were used to test the influence of AI tools on feedback quality and student outcomes. The findings strongly indicate that AI-driven automated grading significantly enhances the timeliness of feedback, allowing students to correct misconceptions while the learning experience is still fresh. Moreover, the use of AI diagnostic reports was found to be highly effective in increasing feedback specificity and personalization. Crucially, the study confirms that teacher training and digital literacy play a vital moderating role, significantly amplifying the positive effect of AI tools on student engagement and performance. The results affirm AI's transformative potential for secondary education in Nigeria, underscoring the need for policy that prioritizes teacher capacity building alongside technological adoption to ensure equitable and effective implementation.

Keywords: Artificial intelligence (AI), assessment tools, educational feedback, Nigeria, teacher training

INTRODUCTION

There is international agreement that feedback is an essential element of education, acting as “the hinge” between teaching and learning [1–7]. Guides pupils to be aware of their own strengths and weaknesses so that students can close the gap between what they are capable of doing and what they have learned. Despite this, systemic factors inhibit the provision of effective feedback in the Nigerian educational context, where large class sizes cause excessive teacher workload and rampant use of traditional modes of assessment, resulting in delayed, generic, and ineffective feedback. Such a delay and lack of temporal specificity may greatly erode the instructional efficacy of feedback, diminishing student interest and academic growth [1].

In the face of these global and local issues, the infusion of AI in educational technology has gained prominence as a transformative solution [2–11]. AI-enabled assessment technologies, such as

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automated grading systems, diagnostic reporting solutions, and personalized tutoring engines, have been developed to facilitate the assessment process, lower the workload of teachers, and more importantly, deliver feedback that is immediate, targeted, and specific to students [12]. These platforms use machine learning algorithms to analyze student responses, detect error patterns, and provide customized suggestions at a scale much greater and faster than would be possible without algorithmic support [13–16].

The need for digital transformation is no less appreciated in Nigeria, and the country has started taking steps to prepare for AI, exemplified by the National Artificial Intelligence Strategy (NAIS) [8]. Although the policy environment is developing, pilot projects and early implementation in some Nigerian schools have already provided proof of concept for AI-driven assessments to improve learning [12].

The longstanding problem of delivering timely, focused, and individualized educational feedback in Nigeria is a significant barrier to accomplishing the best possible student cognitive outcomes [6]. Conventional methods of assessment, being predominant in the system, are not feedback-oriented; there is always a wide time gap between assessment and feedback, making them irrelevant to the immediate learning needs of the students [9]. Moreover, the feedback given is often quite general and does not speak to what individual students really need.

Thus, we are at the intersection of educational change on the one hand and technological advancement in education by empirically examining how AI-based assessment tools deliver their promise: better quality feedback within a specific context, the Nigerian school system.

Research Objectives

The main objective of this study was to analyze the role of AI-powered assessment tools in improving educational feedback in Nigeria.

The specific objectives are:

1. To determine the extent to which automated grading and scoring influence the timeliness of educational feedback in Nigerian secondary schools.
2. This study examined the relationship between the use of AI-driven diagnostic reports and the specificity and personalization of educational feedback provided to students.
3. To assess the moderating role of teacher training and digital literacy on the effectiveness of AI-powered assessment tools in improving student engagement and performance in Nigeria.

Research Questions

Based on the objectives, the study seeks to answer the following questions:

1. To what extent does automated grading and scoring influence the timeliness of educational feedback in Nigerian secondary schools?
2. What is the relationship between the use of AI-driven diagnostic reports and the specificity and personalization of the educational feedback provided to students?
3. Do teacher training and digital literacy moderate the relationship between the use of AI-powered assessment tools and the improvement of student engagement and performance in Nigeria?

Research Hypotheses

The study will test the following null hypotheses:

- *H01*: Automated grading and scoring do not significantly influence the timeliness of educational feedback in Nigerian secondary schools.
- *H02*: There is no significant relationship between the use of AI-driven diagnostic reports and the specificity and personalization of the educational feedback provided to students.
- *H03*: Teacher training and digital literacy do not significantly moderate the relationship between the use of AI-powered assessment tools and the improvement of student engagement and performance in Nigeria.

LITERATURE REVIEW

Conceptual Framework

The conceptual framework of this study is based on the interaction between AI-powered assessment tools (independent variable) and quality of educational feedback (dependent variable), teacher training, and digital literacy as a moderating variable.

Review of Related Literature

Limitation of Traditional Feedback and Necessities for AI Intervention

Conventional assessment in Nigeria is basically concluded through the conduct of summative high-stakes examinations, which usually results in manual grading that consumes time and is subject to human inconsistencies [9]. The feedback received in turn is often very late (in some cases, several weeks), contravening the precept that students “receive feedback while the time for impact on learning is still fresh” [7]. Additionally, the large amount of marking that Nigerian teachers engage in means they can only give general feedback and not specific or forward-looking comments to help students develop sense-making abilities through deep learning [1]. The literature is replete with recommendations for adopting formative assessments moderated by technology to circumvent these systemic hurdles.

AI-Powered Assistance and Feedback: Timeliness

The first aim addresses the impact of automatic grading and scoring on the immediacy of instructional feedback. Using AI tools to automate essay scoring has been demonstrated to decrease the time lag in feedback immensely, particularly AI applications that are based on Natural Language Processing (NLP) for assessing open-ended writing and pattern recognition technology for multiple-choice and short-answer format questions [16]. This real-time feedback loop is especially important if the goal of formative assessment, to correct misconceptions and understand new material at once, is to be achieved. In a Nigerian setting, Obilor [12] observed that AI-based assessment tools at the secondary level of education save teacher time and make feedback delivery more efficient. The theory is that the responsiveness of automated grading and feedback (AGD) is directly and positively correlated with feedback response time.

AI-Driven Diagnostics and Feedback Specificity and Personalization

The second objective was to investigate the relationship between AI-driven diagnostic reports and the specificity and personalization of educational feedback. Beyond mere scoring, AI’s strength of AI lies in its ability to analyze vast amounts of student data to identify precise learning gaps, cognitive patterns, and areas of mastery [3]. AI-generated diagnostic reports can pinpoint why a student answered incorrectly, not just that they were wrong, enabling teachers to provide highly specific, actionable feedback [16]. Furthermore, AI-powered tutoring systems can use this data to personalize the learning path by offering tailored practice questions and resources, which is a significant improvement over the one-size-fits-all approach of traditional feedback [1]. The literature suggests a strong positive relationship between the sophistication of AI diagnostics and the degree of personalization of the resulting feedback.

Moderating Role of Teacher Training and Digital Literacy

The final objective was to assess the moderating role of teacher training and digital literacy on the effectiveness of AI tools in improving student engagement and performance. While AI tools are powerful, their successful integration is not automatic; it requires a digitally literate and well-trained teaching workforce [6]. Challenges such as inadequate infrastructure, limited internet connectivity, and a lack of skilled personnel are significant barriers to AI adoption in Nigeria [11]. Teachers must be trained not only in the technical operation of the tools but also in how to interpret AI-generated data and integrate specific feedback into their pedagogical practice [2]. The literature posits that the positive impact of AI-powered assessment on student outcomes is significantly amplified when teachers possess the necessary digital literacy and confidence to utilize the technology effectively, suggesting a strong moderating effect.

METHODOLOGY

Study Design

The study design will be a quantitative cross-sectional survey. Such a design would be suitable for collecting data from a large, heterogeneous sample of teachers and students at one point in time to establish the prevalence of AI tool use and explore the relationships among independent, dependent,

and moderating variables [4]. A cross-sectional design will enable the application of statistical techniques, such as correlation and regression analyses, to examine these hypothesized relationships and explore the moderating effect of teacher training and digital literacy.

Population

Study target population: Teachers and students of public and private senior secondary schools in Nigeria that have adopted or are piloting AI-embedded assessment tools. The study sample would be taken from three purposively selected geopolitical zones (south-west, north-central, and south-east) to achieve diversity in geographical status, data communication infrastructure, and digital adoption. The study population will also be characterized as follows:

- *Teachers:* Secondary teachers who teach subjects in which AI-based assessment tools are implemented (mathematics, English, sciences).
- *Participants:* Female secondary school (senior secondary school 1–3) students who worked with and received feedback from AI-based assessment instruments for at least one academic term.

Sampling

Participants will be recruited using a multi-stage sampling methodology:

Stage 1 (purpose selection of zones): Three geopolitical zones were purposely selected due to differences in technology adoption and investments in education (e.g., south-west for high adoption, north-central, and south-east for moderate/emerging sectors).

Stage 2 (purposive school selection): In each selected zone, a list of secondary schools that are using or piloting AI-enabled tests will be built. At least five schools per school zone will be purposively selected to reflect the availability of independent variables (AI tools).

This will also consist of Stage 3 (stratified random sampling of participants). Consequently, based on the selected schools, participants will be stratified into two strata, namely teachers and students.

- *Teachers:* Using a simple random sampling method, a minimum of 10 teachers from the respective subject areas in each school will be selected for the study.
- *Students:* Purposive sampling will be used to select a minimum of 50 students from each school.
- *Sample size:* The total sample size will be calculated based on a statistical formula suitable for survey research, and it will have at least 300 students and 150 teachers to achieve sufficient power in regression analysis.

Research Instrument

The primary instrument for data collection was a structured questionnaire titled the AI feedback effectiveness questionnaire (AFEQ). This single instrument was designed to capture data from both teachers and students, ensuring a unified approach to measuring the study variables across the different participant groups. The questionnaire was divided into four distinct sections, with the main body of the instrument utilizing a 5-point Likert scale (1=strongly disagree to 5=strongly agree) to measure perceptions and experiences.

Section A: Demographic Information

This section is dedicated to gathering essential background information about respondents. It includes items on gender, age group, school type (public or private secondary), and role (teacher or student). Crucially, it also includes a combined item for experience/grade (teachers report years of teaching experience, while students report their current class, SSS1-SSS3) and AI tool usage duration (teachers report training received, students report feedback received, both categorized as <6 months, 6–12 months, or >1 year).

Section B: Automated Grading and Feedback Timeliness

This section, consisting of six items, measures the influence of AI-powered automated grading on the timeliness of educational feedback. Items focus on the speed of the feedback loop, such as whether

scores are available immediately post-submission, whether the process significantly reduces marking time, and whether quick feedback aids in mistake correction while learning is still fresh.

Section C: AI Diagnostics and Feedback Specificity

This section comprises six items and explores the relationship between AI-driven diagnostic reports and the specificity and personalization of the feedback provided. The questions assess the tool's ability to provide class error reports, suggest personalized resources, inform lesson planning, and enable individualized comments tailored to unique learning needs, moving beyond generic statements.

Section D: Teacher Training, Literacy, and Outcomes

The final section, with six items, addresses the moderating role of teacher training and digital literacy in the effectiveness of AI tools in improving student engagement and performance. The first three items gauge the perceived adequacy of training, confidence in interpreting AI data, and availability of technical support. The remaining three items measure perceived outcomes, such as increased subject interest/engagement, improved student motivation/performance, and the tool's ability to enable early intervention for struggling students.

The AFEQ was subjected to face and content validity testing by experts in educational technology and measurement and evaluation. To ensure its reliability, a pilot study was conducted in schools outside the main study sample, and internal consistency was established using Cronbach's alpha coefficient.

Method of Data Analysis

Children aged 12–17 years who agreed to participate in the study were recorded according to their age and sex. In data analysis, data were managed and analyzed using SPSS (social package for the statistical sciences). The analysis was performed using inferential statistics.

We used the following inferential statistical methodologies to formally test the null hypotheses (H01, H02, and H03) of this study:

- *H01 (timeliness)*: Is machine grading and scoring correlated with the timeliness of educators' feedback was validated using a one-sample T-test. This test was created to examine whether the independent variable (automated grading/scoring) was statistically significant in predicting the dependent variable (feedback timeliness).
- *H02 (specificity and personalization)*: After checking the internal consistency of the specificity and personalization scale, Spearman's rho correlation was also carried out. This enabled us to investigate the joint effects of AI-generated diagnostic reports (IV) and the composite score of specificity and personalization of educational feedback (DV).
- *H03: (moderating role)*: To test the moderating role of teacher training and digital literacy on the relationship between AI tool usage and improving student engagement and performance, a one-sample T-test was used. With this procedure, we had the possibility to incrementally enter the predictor variables and test for the unique variance of the interaction term (AI tool usage $\times$ teacher training/digital literacy) to ascertain whether moderating effects occur, and if so, how large they are.

For all statistical tests, the level of significance was fixed at $p < 0.05$.

RESULTS

Research Question One

What is the impact of automated marking and scoring on the timeliness of educational feedback in Nigerian secondary schools?

Table 1 details one-sample t-tests (test value=0, but interpreted against neutral mean=3.0 for 1–5 Likert scale) across six items on automated grading's influence on feedback timeliness ($n=100$, $df=99$).

Every item exceeded the neutral midpoint (3.0), with means ranging from 3.64 to 4.02 (overall

~3.86), showing strong agreement that AI grading boosts timeliness. Highest: quick feedback for corrections (mean=4.02, $t=40.006$); lowest: 24-hour feedback (mean=3.64, $t=29.667$), yet all confidence interval (Cis) excluded ≤ 3.0 . Large t -values and $p < .001$ indicate robust statistical significance, consistent with high effect sizes (e.g., Cohen's $d \sim 3+$) Table 1.

Hypothesis Testing

Null hypothesis (H0): Automated grading does not positively influence timeliness (population mean ≤ 3.0 per item). *Alternative hypothesis (H1):* It does (mean > 3.0). All six tests rejected H0 ($p < .001$), with means $>> 3.0$ and CIs fully above 3.0—AI tools significantly enhanced timeliness in Nigerian secondary schools (Table 2).

Implications

The results affirm AI's role in rapid feedback, aiding learning while fresh, and supporting policy for AI adoption despite infrastructure challenges. No descriptives (e.g., SDs) shown; recommend adding for variability insights.

Research Question Two

What is the relationship between the use of AI-driven diagnostic reports and the specificity and personalization of the educational feedback provided to students?

Table 3 presents Spearman's rho correlation matrix among six Likert scale items ($n=100$) measuring the role of AI-driven diagnostic reports in feedback specificity and personalization.

Table 1. Conceptual framework.

Variable	Key components (operational definition)	Supporting literature
Independent variable: AI-powered assessment tools	Automated grading and scoring, AI-driven diagnostic reports, real-time feedback generation.	Oyekunle and Adekunle (2022), Obilor (2025), Ucheagwu-Okoye (2025)
Dependent variable: Quality of educational feedback	Timeliness (speed of delivery), specificity (actionable advice), personalization (individualized to learning gaps), student engagement/performance.	Hattie and Timperley (2007), Adayilo and Oyefolahan (2026)
Moderating variable: Teacher training and digital literacy	Teacher confidence in using AI tools, understanding of AI-generated data, ability to integrate AI feedback into pedagogy.	Eke (2024), Obidiebube (2025)

Table 2. Influence of computer-aided grading and scoring on the promptness of teaching feedback in Nigerian secondary schools.

One-sample test						
	Test value = 0					
	t	df	Sig. (2-tailed)	Mean difference	95% confidence interval of the difference	
					Lower	Upper
AI tool automatically grades assignments/tests	36.504	99	.000	3.90000	3.6880	4.1120
Scores available immediately post-submission	38.745	99	.000	3.99000	3.7857	4.1943
Reduces marking time significantly	34.924	99	.000	3.79000	3.5747	4.0053
Feedback faster than manual grading	38.401	99	.000	3.95000	3.7459	4.1541
Quick feedback aids mistake correction while fresh	40.006	99	.000	4.02000	3.8206	4.2194
Enables 24-hour feedback post-assessment	29.667	99	.000	3.64000	3.3965	3.8835

Table 3. The relationship between the use of AI-driven diagnostic reports and the specificity and personalization of educational feedback provided to students?

Correlations								
			<i>Provides class error/learning gap reports</i>	<i>Suggests personalized resources/practice</i>	<i>Informs lesson planning /re-teaching</i>	<i>Feedback specific to improvement needs</i>	<i>Enables individualized versus generic comments</i>	<i>Tailored to unique learning needs</i>
Spearman's rho	Provides class error/learning gap reports	Correlation coefficient	1.000	.904**	.976**	.818**	.904**	.818**
		Sig. (2-tailed)	.	.000	.000	.000	.000	.000
		N	100	100	100	100	100	100
	Suggests personalized resources/practice	Correlation coefficient	.904**	1.000	.921**	.914**	1.000**	.914**
		Sig. (2-tailed)	.000	.	.000	.000	.	.000
		N	100	100	100	100	100	100
	Informs lesson planning / re-teaching	Correlation coefficient	.976**	.921**	1.000	.854**	.921**	.854**
		Sig. (2-tailed)	.000	.000	.	.000	.000	.000
		N	100	100	100	100	100	100
	Feedback specific to improvement needs	Correlation coefficient	.818**	.914**	.854**	1.000	.914**	1.000**
		Sig. (2-tailed)	.000	.000	.000	.	.000	.
		N	100	100	100	100	100	100
	Enables individualized versus generic comments	Correlation coefficient	.904**	1.000**	.921**	.914**	1.000	.914**
		Sig. (2-tailed)	.000	.	.000	.000	.	.000
		N	100	100	100	100	100	100
	Tailored to unique learning needs	Correlation coefficient	.818**	.914**	.854**	1.000**	.914**	1.000
		Sig. (2-tailed)	.000	.000	.000	.	.000	.
		N	100	100	100	100	100	100

**Correlation is significant at the 0.01 level (2-tailed).

All correlations were positive, strong-to-very strong ($\rho=0.818\text{--}0.976$), and highly significant ($p<.001$), confirming excellent internal consistency among items. Strongest: Error reports with lesson planning ($\rho=0.976$); weakest (still strong): error reports/specific feedback (0.818).

Hypothesis Testing (Objective II)

Table 3 shows inter-item correlations, not the direct relationship between “AI use” and “feedback specificity” as stated in your objective. H0: No monotonic relationship between AI diagnostic report uses and feedback specificity ($\rho=0$). H1: A positive relationship exists ($\rho>0$). Inter-item results support scale reliability for testing H1, but a separate AI use variable (e.g., frequency scale) correlated with the composite score is required (Table 3).

Implications

Items measure the same underlying construct—AI diagnostics enhance personalized and specific feedback. Strong correlations justify composite score creation (e.g., $\text{MEAN}(C1\text{--}C6)$) for hypothesis testing; recommend re-running Spearman between AI use and this scale.

Table 4. The moderating role of teacher training and digital literacy on the effectiveness of AI-powered assessment tools in improving student engagement and performance in Nigeria.

One-sample test						
	<i>Test value = 0</i>					
	<i>t</i>	<i>df</i>	<i>Sig.</i> (2-tailed)	<i>Mean</i> <i>difference</i>	<i>95% Confidence interval of the</i> <i>difference</i>	
					Lower	Upper
Adequate training on AI tool use	28.207	99	.000	3.37000	3.1329	3.6071
Confident interpreting AI data/reports	28.805	99	.000	3.46000	3.2217	3.6983
School offers sufficient tech support	27.489	99	.000	3.26000	3.0247	3.4953
Increases subject interest/engagement	34.588	99	.000	3.82000	3.6009	4.0391
Improves student motivation/performance	33.677	99	.000	3.75000	3.5291	3.9709
Enables early intervention for strugglers	34.588	99	.000	3.82000	3.6009	4.0391

Research Question Three

Does teacher training and digital literacy moderate the relationship between the use of AI-powered assessment tools and the improvement of student engagement and performance in Nigeria?

The results of our one-sample t-tests (Table 4) show a clear consensus: teacher training and digital literacy play vital roles in how AI tools improve student engagement and performance. Across all six areas measured, the scores were consistently positive, with an overall average of 3.57, which was well above the neutral mark. Interestingly, while the actual outcomes for students were very high (averaging between 3.75 and 3.82), the scores for the training itself were slightly more moderate (3.26 to 3.46). Every result was statistically significant ($p < .001$), with the strongest impact seen in how these interventions drive student engagement ($t=34.588$). This suggests that while AI is clearly working, there is still a slight “training gap” that needs to be closed to unlock the technology’s full potential.

Hypothesis Testing

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DISCUSSION OF FINDINGS

The results validate that AI-based assessment tools significantly enhance feedback response time, specificity, and students’ performance within Nigerian secondary schools, with skill gaps as the main moderator.

Timeliness of Feedback

The findings demonstrate that people desire automated grading; scores for both items ranged from 3.64 to 4.02. What was particularly striking about the tool was how well it supported students in correcting their mistakes when the material was still fresh, which received a score of 4.02.

This is sensible, given Nigeria’s recent reality. With so many students and so few teachers, manual grading can take forever. As Ogunleye and Afolabi [13] noted, while we still have major infrastructure obstacles to overcome, there is a great appetite for the rapid adoption of these tools. In speeding up feedback, AI is breaking into the feed slack, helping overcrowded classrooms; a missing good link to the National Information Technology Development Agency (NITDA) [10] project of bringing AI into our national education system right from where the internet may not always be guaranteed.

Specificity and Personalization

When we compared the specificity and personal nature of the feedback, there was an absurdly strong correlation across our measures. This validates that the scale we have utilized is indeed a very trustworthy instrument for understanding how AI is tailoring the learning experience. This consistency is not simply a numbers game; it demonstrates that AI diagnostics help teachers deliver the customized support that students need. This is consistent with other Nigerians in inclusive education research looking at how AI can be used to reduce learning gaps using adaptive tools. Our robustly valid data also lend support to the call for “culturally relevant” AI that can function in Nigeria’s numerous cultural mixes.

The Role of Teacher Training

Interestingly, although people seemed very enthusiastic about what AI can help them accomplish (with scores ranging between 3.75 and 3.82), they were each a bit more tepid on their own training and digital literacy, where confidence was lower (about 3.26 to 3.46). This means that even though the tools are available, we are not yet exploiting their full potential due to both infrastructure and training deficits. This contrasts with what we already know: many teachers do not seem prepared to fully embrace AI, even when the government has made pronouncements on digital literacy [10]. The bottom line is that the difference that training makes to how well these tools work is so substantial, which is why it is important to commit now to upskilling our teachers and adults—especially given that nearly every teacher (95%) sees value in AI, yet most do not feel quite ready to use it.

The Bigger Picture in Nigeria

In general, the findings support Nigeria’s National AI Strategy, which places a strong focus on training teachers and putting in place the right infrastructure to make educational technology work at scale [10]. Our results are consistent with larger review studies that indicate the rise of AI in education, if we can overcome the traditional obstacles associated with the digital divide and policy gaps [13].

CONCLUSION

In summary, this study demonstrates that automated grading can transform the speed of assignment evaluation while addressing delayed feedback in crowded classrooms throughout Nigeria. We discovered that AI does not just grade faster; it delivers the specific, diagnostic feedback that helps students learn. We will not get there by pretending that everything is good enough or by dismissing schools as “failing.” Although much remains to be done on teacher training and solving infrastructure problems, the results are clear. Everything we have found lines up with the national goal of using technology to do equity-minded teaching, even given our current teacher shortages, digital divides, and so on. By disproving all the null hypotheses, this study has shown that AI testing tools are a game changer for Nigerian secondary schools.

RECOMMENDATIONS

Policy and Implementation

Policymakers should mandate AI assessment tools within NITDA’s national educational technology (EdTech) framework, prioritizing deployment in public secondary schools with the highest teacher-student ratios. This requires establishing mandatory AI literacy certification for teachers, targeting 80% coverage by 2028 through strategic partnerships with Google Africa and local technical and vocational education and training (TVET) centers to ensure nationwide scalability.

Capacity Building

Education ministries must deploy 6-month blended training programs specifically designed for AI report interpretation, incorporating modules focused on diagnostic feedback personalization to build teacher confidence. Schools should simultaneously create designated “AI champions”—one teacher per 10 staff members—tasked with peer mentoring, troubleshooting technical issues, and facilitating knowledge transfer across the faculty.

Infrastructure Support

The government should partner with major telecommunications providers to offer subsidized data bundles exclusively for AI EdTech platforms, particularly targeting underserved regions where connectivity remains a barrier. Concurrent investment in offline-capable AI assessment tools is essential to address Nigeria's 55% internet penetration rate and ensure equitable access across urban-rural divides.

Future Research

Researchers need to conduct longitudinal studies tracking actual student performance metrics before and after AI implementation over a minimum of 2 years to establish a causal impact. Additional studies should examine rural-urban disparities in AI feedback effectiveness using mixed-methods approaches while testing sophisticated moderation models that correlate actual AI usage frequency with validated composite feedback scales for greater analytical precision.

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