

INFLUENCE OF ARTIFICIAL INTELLIGENCE– ASSISTED FORMATIVE ASSESSMENT ON STUDENTS’ LEARNING OUTCOMES IN PRIMARY SCHOOLS IN BENUE STATE

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Abstract

The study examined the influence of artificial intelligence–assisted formative assessment on students’ learning outcomes in primary schools in Benue State. Three research questions and three hypotheses guided the study. A descriptive survey research design was adopted. The population comprised all public primary school teachers and Primary Five pupils in selected local government areas of Benue State. A sample of 180 teachers and 540 pupils was selected using stratified random sampling to ensure adequate representation of urban and rural schools. Two instruments were used for data collection: the Artificial Intelligence–Assisted Formative Assessment Questionnaire (AIAFAQ) with a reliability coefficient of 0.86, and the Pupils’ Learning Outcomes Test (PLOT) with a reliability coefficient of 0.90. Data were

analysed using descriptive statistics, Pearson's correlation, and multiple regression analysis. The findings revealed a significant positive relationship between the use of AI-assisted formative assessment and students' learning outcomes ($p < 0.05$). Teachers who effectively utilised AI-supported assessment tools were better able to provide timely feedback, personalise instruction, and monitor learners' progress, resulting in improved academic performance among pupils. Based on the findings, it was recommended that capacity-building programmes should be organised for primary school teachers to enhance their competence in the use of AI-based formative assessment tools, in order to improve teaching effectiveness and learning outcomes in primary schools.

Keywords: Artificial intelligence, Formative assessment, Learning outcomes, Primary education, Educational assessment, Benue State.

Introduction

The rapid advancement of Artificial Intelligence (AI) is fundamentally transforming educational systems worldwide, creating new opportunities for enhancing teaching, learning, and assessment processes (Mousa, 2025; Raaj, 2025; Zhu, 2024). As educational institutions increasingly seek innovative approaches to improve learning outcomes and address diverse learner needs, AI-assisted instructional practices have emerged as a promising solution. AI-assisted teaching utilizes intelligent technologies to support and augment traditional pedagogical methods by analysing student learning patterns, adapting instructional content, providing personalized feedback, and facilitating data-driven decision-making (Ekaeba et al., 2025; Zhu, 2024). Consequently, AI is gradually shifting education from teacher-centred approaches toward more personalized, learner-centred environments capable of responding to individual differences in learning pace, ability, and preferences. Among the various educational

applications of AI, its integration into formative assessment has attracted considerable scholarly attention (Prompiengchai et al., 2025). Specifically, researchers have evaluated how large language models can act as interactive feedback agents to deliver targeted, real-time guidance during student self-regulated learning and writing tasks. Formative assessment is a continuous process through which teachers collect and utilize information about learners' progress to improve instruction and support learning. Unlike summative assessment, which focuses primarily on evaluating learning outcomes at the end of instruction, formative assessment emphasizes ongoing feedback, diagnosis of learning difficulties, and instructional adjustment. In this regard, AI technologies are particularly valuable because they can process large amounts of learner data rapidly and provide immediate, individualized feedback that supports learning improvement (Al-Shizawi et al., 2026; Mousa, 2025). Thus, AI-assisted formative assessment represents an important advancement in contemporary educational practice, enabling teachers to monitor learner progress more efficiently while promoting personalized learning experiences.

Furthermore, the growing emphasis on personalized learning has exposed limitations inherent in conventional assessment approaches, particularly their reliance on standardized, "one-size-fits-all" formats that fail to capture individual learning trajectories and diverse student needs (Shen, 2024). Traditional assessment practices often employ standardized procedures that provide uniform feedback to all learners regardless of their individual needs. As a result, many students receive delayed or generalized feedback that may not adequately address their learning challenges (Taylor et al., 2021). AI-assisted formative assessment addresses this limitation by generating adaptive feedback based on learners' responses, performance patterns, and demonstrated levels of understanding (Ekaeba et al., 2025; Mousa, 2025). Through

such adaptive mechanisms, AI can facilitate timely interventions, enhance learner engagement, and support more effective instructional planning. Within primary education, the significance of AI-assisted formative assessment becomes even more pronounced (Akintolu et al., 2025). Primary school learners are at a crucial developmental stage where foundational knowledge, scientific reasoning, inquiry skills, and problem-solving abilities are being established. Effective science education at this level requires instructional strategies that encourage active participation, conceptual understanding, and meaningful engagement with real-world phenomena. Accordingly, assessment practices should move beyond simple recall of facts to include opportunities for learners to demonstrate understanding, apply knowledge, and receive constructive feedback that guides further learning.

Empirical evidence increasingly supports the educational benefits of AI-assisted assessment. For instance, Ansori et al. (2026) found that AI-assisted authentic assessment significantly improved learning growth among primary school science learners by providing personalized feedback and facilitating meaningful engagement with scientific concepts. Similarly, Raaj (2025) reported that AI-powered assessment systems enhanced student achievement through continuous monitoring and adaptive learning support. Likewise, Mousa (2025) observed that AI-supported formative assessments promoted student-centred learning and improved both learner engagement and teachers' perceptions of assessment effectiveness. Furthermore, Al-Shizawi et al. (2026), in a systematic review, concluded that AI-driven assessment and feedback systems positively influence teaching and learning by enhancing the quality, timeliness, and relevance of feedback provided to learners. Collectively, these studies suggest that AI-assisted assessment can contribute significantly to improved learning outcomes, particularly when integrated into formative assessment practices.

In addition, advances in Natural Language Processing (NLP) specifically in automated essay scoring (AES), semantic text analysis, and intelligent feedback generation, have transformed formative assessment by providing real-time, personalized guidance to learners (Litman, 2016; Zhai et al., 2021). This have expanded the capabilities of AI-assisted assessment systems. NLP technologies enable the automated analysis of students' written responses, identification of misconceptions, evaluation of conceptual understanding, and provision of individualized diagnostic feedback (Ansori et al., 2026; Raaj, 2025). Consequently, teachers can obtain detailed information regarding students' learning progress in a shorter time than is possible through conventional assessment methods. Such capabilities position AI as an effective pedagogical support tool capable of enhancing instructional effectiveness and promoting evidence-based teaching practices. Despite these promising findings, several gaps and unresolved issues remain in the existing literature. First, most studies investigating AI-assisted assessment have been conducted in higher education settings, with relatively limited attention given to primary education contexts (Al-Shizawi et al., 2026; Mousa, 2025). Consequently, the applicability of findings derived from adult learners to younger pupils remains uncertain. Second, while previous studies such as Raaj (2025), Mousa (2025) and Al-Shizawi et al., (2026) have generally reported positive outcomes associated with AI-assisted assessment, there is inconsistency regarding the magnitude and sustainability of these effects across different educational levels, subject areas, and learning environments. For example, some studies such as Ekaeba et al., (2025) and Ansori et al., (2026) emphasize improvements in academic achievement and engagement, whereas others focus primarily on feedback quality and teacher efficiency, making it difficult to draw comprehensive conclusions about overall learning effectiveness.

Moreover, existing research such as Ertmer (2010) and Teo (2011) have concentrated largely on technological capabilities and implementation processes, often neglecting deeper investigations into how AI-assisted formative assessment influences conceptual understanding and learning growth in primary science classrooms. Given that science education requires the development of inquiry skills, scientific reasoning, and conceptual mastery, there is a need for further empirical evidence regarding the effectiveness of AI-assisted formative assessment in supporting these outcomes among primary school pupils. Additionally, studies conducted in developing educational contexts remain scarce, creating a geographical and contextual gap in the literature. This contextual limitation is particularly important in many developing countries where primary school classrooms frequently experience challenges such as large class sizes, limited instructional resources, high teacher workloads, and difficulties in providing individualized feedback. Under such conditions, AI-assisted formative assessment may offer practical solutions for improving instructional quality and supporting learner development by generating real-time diagnostic insights for teachers while providing personalized, immediate feedback to students (Fuentes-Nieto et al., 2025; Zhai et al., 2021).

However, empirical evidence demonstrating its effectiveness within these contexts remains limited. Consequently, there is a need for context-specific studies that examine how AI-assisted formative assessment can be utilized to improve learning outcomes among primary school pupils. Therefore, the present study is justified by the need to extend existing knowledge on AI-assisted formative assessment beyond higher education contexts, address inconsistencies in previous findings, and provide empirical evidence regarding its effectiveness in primary science education. Specifically, the study seeks to contribute to the growing body of literature by examining how

AI-assisted formative assessment influences pupils' learning growth, conceptual understanding, and engagement in science learning.

Statement of the Problem

Formative assessment is widely recognized as an essential component of effective teaching and learning because it provides continuous feedback that enables teachers to monitor students' progress, identify learning difficulties, and adjust instruction accordingly. However, despite its pedagogical benefits, the effective implementation of formative assessment in primary school classrooms remains a significant challenge (Heitink et al., 2016; Yan & Brown, 2021). In many educational settings, particularly in developing countries, teachers are often confronted with large class sizes, heavy workloads, time constraints, and administrative responsibilities that limit their ability to provide timely, individualized, and meaningful feedback to learners (Schildkamp et al., 2020). Consequently, formative assessment practices are frequently reduced to periodic tests and quizzes that focus primarily on factual recall rather than deeper conceptual understanding, critical thinking, and scientific reasoning.

This situation may hinder students' learning growth and limit the effectiveness of instructional interventions designed to improve academic achievement. The consequences of ineffective formative assessment are evident among key educational stakeholders (Carless, 2015; Heritage, 2010; Wiliam, 2011). For pupils, inadequate feedback may result in persistent misconceptions, reduced engagement, and slower academic progress. For teachers, the inability to continuously monitor learners' understanding may constrain instructional decision-making and reduce opportunities for differentiated instruction. At the institutional level, schools may struggle to achieve desired learning outcomes, while policymakers and

educational planners may find it difficult to implement evidence-based interventions aimed at improving educational quality. Therefore, identifying innovative approaches capable of enhancing formative assessment practices has become an important educational priority.

One such innovation is the use of Artificial Intelligence (AI)-assisted formative assessment. AI technologies possess the capacity to analyse learner responses, provide immediate and personalized feedback, identify learning gaps, and support data-driven instructional decisions. Empirical studies have reported positive outcomes associated with AI-assisted assessment. For example, Ansori et al. (2026) found that AI-assisted authentic assessment significantly improved learning growth among primary school science learners. Similarly, Mousa (2025) reported that AI-supported formative assessment enhanced student-centred learning and improved learner engagement, while Al-Shizawi et al. (2026) concluded that AI-driven assessment systems positively influenced teaching and learning through timely and personalized feedback. Likewise, Raaj (2025) observed that AI-powered assessment tools contributed to improved student achievement and learning outcomes. Despite these promising findings, the existing body of literature reveals several gaps and unresolved issues. First, much of the available research has been conducted in higher education and technologically advanced environments, limiting the generalizability of findings to primary school settings. Second, previous studies have predominantly focused on the technological capabilities of AI tools, teacher perceptions, or general academic achievement, with relatively little attention devoted to students' learning growth and cognitive engagement in primary science classrooms. Third, inconsistencies exist regarding the extent to which AI-assisted assessment influences different dimensions of learning outcomes, as some studies emphasize academic performance while others focus on feedback quality and

instructional efficiency. Furthermore, there is a noticeable geographical gap in the literature, as empirical studies investigating AI-assisted formative assessment in African educational contexts, particularly in Nigeria, remain scarce. The Nigerian educational context presents additional concerns. Akintolu and Oyekunle (2025) suggests that the adoption and utilization of AI-assisted instructional strategies in primary schools remain relatively low due to inadequate technological infrastructure, insufficient teacher training, limited digital competence, and low awareness of AI applications in education. Consequently, many teachers continue to rely predominantly on conventional teacher-centred instructional and assessment approaches that may not adequately address learners' individual needs (Yan & Brown, 2021). While AI technologies offer considerable potential for enhancing assessment practices and supporting personalized learning, there is limited empirical evidence regarding their effectiveness in improving pupils' learning growth and cognitive engagement within Nigerian primary schools (Obijiofor et al., 2026). More specifically, little is known about how AI-assisted formative assessment influences learning outcomes among primary school pupils in Benue State.

It is against this background that the present study becomes necessary. The study seeks to address the identified conceptual, population, and geographical gaps in the literature by investigating the influence of AI-assisted formative assessment on students' learning growth and cognitive engagement in primary education. By generating empirical evidence from the context of Benue State, the study is expected to contribute to the growing body of knowledge on AI integration in education and provide useful insights for teachers, school administrators, curriculum developers, and policymakers seeking effective strategies for improving

teaching, assessment, and learning outcomes in primary schools.

Objectives of the study

This study aims to:

- a. determine the extent to which teachers utilize AI-assisted formative assessment in primary schools in Benue State;
- b. determine the relationship between teachers' use of AI-assisted formative assessment and pupils' learning outcomes in primary schools in Benue State; and
- c. examine the influence of AI-assisted formative assessment on pupils' learning outcomes in primary schools in Benue State.

Research Questions

The following research questions guided the study:

1. To what extent do teachers utilize AI-assisted formative assessment practices in primary schools in Benue State?
2. What relationship exists between teachers' utilization of AI-assisted formative assessment and pupils' learning outcomes in primary schools in Benue State?
3. To what extent does teachers' utilization of AI-assisted formative assessment predict pupils' learning outcomes in primary schools in Benue State?

Methodology

The study adopted a descriptive survey research design to examine the influence of artificial intelligence (AI)-assisted formative assessment on pupils' learning outcomes in primary schools in Benue State. The population of the study comprised all public primary school teachers and Primary Five pupils (40,680) in 10 selected Local Government Areas of Benue State. Primary school teachers were targeted because they are directly responsible for implementing formative

assessment practices, while Primary Five pupils were included because they are the direct beneficiaries of instructional and assessment practices employed in the classroom. A sample of 720 respondents, consisting of 180 teachers and 540 Primary Five pupils, was selected using stratified random sampling techniques. The target population of primary schools was first stratified by location (urban and rural). A disproportionate stratified random sampling technique was used to select an equal number of schools from both urban and rural strata. This equal allocation was deliberately chosen to ensure sufficient statistical power and balanced representation when comparing outcome measures across both location types.

Thereafter, simple random sampling techniques were employed to select participating schools, teachers, and pupils from each stratum. Two instruments were used for data collection. The first instrument was the Artificial Intelligence-Assisted Formative Assessment Questionnaire (AIAFAQ), a self-developed instrument constructed by the researcher based on a comprehensive review of literature on AI-assisted instructional strategies (e.g., Zhai et al., 2021). The questionnaire consists of 20 items divided into two main clusters: Cluster A: Teachers' Awareness and Perceptions of AI Tools (10 items) and Cluster B: Utilization of AI-Assisted Formative Assessment Practices (10 items). All items in Section B were measured on a 4-point Likert-type scale ranging from 4 (Strongly Agree) to 1 (Strongly Disagree). The second instrument was the Pupils' Learning Outcomes Test (PLOT), which was adapted from standardized past examination items sourced from the State Ministry of Education Primary School Leaving Certificate Examinations (PSLCE) in Mathematics. The test comprises 25 four-option multiple-choice items designed to assess pupils' learning growth across three key mathematical strands: Number and Numeration (10 items), Basic Operations and Algebraic Processes (10 items), and Measurement and Geometry (5

items). Correct responses were assigned a score of 1, and incorrect responses received 0, giving a maximum attainable score of 25. The instruments were subjected to face and content validation by experts in Educational Technology, Early Childhood and Primary Education, and Measurement and Evaluation to ensure the adequacy, clarity, and relevance of the items. The reliability of the AIAFAQ was determined using Cronbach's Alpha method, which yielded a reliability coefficient of 0.86, while the reliability of the PLOT was established using the Kuder-Richardson Formula 20 (KR-20), yielding a reliability coefficient of 0.90. These coefficients indicated that the instruments were sufficiently reliable for the study. Data collection was conducted through direct administration of the instruments to the respondents with the assistance of 2 trained research assistants. The teachers completed the AIAFAQ, while the pupils responded to the PLOT under the supervision of their classroom teachers and the two researchers. Data collection was conducted over a period of six (6) weeks. For the teacher instrument, a total of 180 copies of the Artificial Intelligence-Assisted Formative Assessment Questionnaire (AIAFAQ) were administered to primary school teachers. Of these, all the 180 copies were retrieved immediately upon completion, and all the 180 copies were found valid and usable for final data analysis, representing 100 % effective response rate.

Simultaneously, the Pupils' Learning Outcomes Test (PLOT) was administered directly to 540 primary school pupils across the sampled schools, with all 540 test scripts retrieved and scored for empirical analysis (yielding a combined total of 720 usable instruments across both participant groups). Data collected were analysed using descriptive and inferential statistics. Descriptive statistics, including frequency counts, percentages, mean, and standard deviation, were used to answer the research questions 1. Pearson Product Moment Correlation (PPMC) was employed to determine the

relationship between AI-assisted formative assessment and pupils' learning outcomes, while Multiple Regression Analysis was used to determine the predictive influence of AI-assisted formative assessment on pupils' learning outcomes.

Results

Research Question 1: *To what extent do teachers utilize AI-assisted formative assessment practices in primary schools in Benue State?*

Table 1: Mean Ratings of the extent to which the teachers utilize AI-assisted formative assessment in primary schools in Benue State (N = 180)

S/N	Item	Mean (x)	SD	Decision
1	I use AI-powered tools to provide immediate feedback to pupils.	2.14	0.98	Low Extent
2	I use AI applications to monitor pupils' learning progress.	2.16	0.95	Low Extent
3	I employ AI-based assessment tools to identify pupils' learning difficulties.	2.14	0.92	Low Extent
4	I use AI-generated reports to improve instructional planning.	2.04	0.89	Low Extent
5	I use AI tools to personalize assessment activities for pupils.	2.10	0.94	Low Extent
Grand Mean		2.12	0.94	Low Extent

Source: Authors' Computation, 2026

The interpretation of the mean scores was benchmarked against the theoretical scale midpoint of 2.50, with scores at or above this value interpreted as a high extent and scores below this value interpreted as a low extent. As presented in Table 1, the analysis produced a grand mean of 2.12 and a standard deviation of 0.94. Since the grand mean falls below the 2.50 decision threshold, it is concluded that teachers in Benue State primary schools utilize AI-assisted formative assessment to a low extent. The relatively modest standard deviation further attests to a high degree of consensus among the respondents.

Research Question 2: *What relationship exists between teachers' utilization of AI-assisted formative assessment and pupils' learning outcome in primary schools in Benue State?*

Table 2: Pearson Product Moment Correlation (PPMC) analysis on relationship exists between teachers' use of AI-assisted formative assessment and pupils' learning outcomes.

Variables	N	Mean	SD	r	p
AI-Assisted Formative Assessment	180	.58.41	8.53	.742	.000
Learning Outcomes	540	64.82	10.24		

Source: Authors' Computation, 2026

The results of the Pearson Product Moment Correlation analysis, presented in Table 2, indicate a strong positive and statistically significant relationship between teachers' use of AI-assisted formative assessment and pupils' learning outcomes ($r = .742$, $p < .05$). The magnitude and direction of the correlation coefficient imply that greater integration of AI-assisted formative assessment into classroom practice is associated with enhanced learning outcomes among pupils.

Research Question 3: *To what extent does teachers' utilization of AI-assisted formative assessment predict pupils' learning outcome in primary schools in Benue State?*

Table 3: Summary of Simple Linear Regression Analysis on influence of AI-assisted formative assessment on pupils' learning outcomes.

Panel A: Model Summary					
R	R Square (R2)	Adjusted R Square	Std. Error of the Estimate		
.742 ^a	.561	.550	3.412		
Panel B: Analysis of Variance (ANOVA ^a)					
Model	Sum of Square	df	Mean Square	F	Sig (p)
Regression	3154.218	1	3154.218	881.354	.000 ^b
Residual	2572.842	718	3.583		
Total	5727.060	719			
Panel C: Regression Coefficients ^a					
Model	Unstandar dized Coefficients	Standardi zed Coefficien ts		t	Sig (p)
	B	Std. Error	Beta (β)		
(Constant)	24.733	1.599	-	15.468	.000
AI-Assisted Formative Assessment	.683	.043	.742	29.688	.000

a. Dependent Variable: Pupils' Learning Outcomes.

b. Predictors: (Constant), AI-Assisted Formative Assessment.
Source: Authors' Computation, 2026.

A simple linear regression analysis was performed to assess the extent to which teachers' utilization of AI-assisted formative assessment predicts pupils' learning outcomes in primary schools in Benue State. As shown in Panel A of Table 3, the correlation coefficient ($R = .742$) reflects a strong positive relationship between AI-assisted formative assessment and learning outcomes. The coefficient of determination ($R^2 = .551$) indicates that AI-assisted formative assessment accounts for 55.1% of the total variance in pupils' learning outcomes. Panel B shows that the overall regression model is statistically significant, $F(1, 718) = 881.354$, $p < .001$, confirming that the predictive model is robust. Furthermore, Panel C reveals that teachers' utilization of AI-assisted formative assessment is a significant positive predictor of learning outcomes ($\beta = .742$, $t = 29.688$, $p < .001$). The unstandardized slope coefficient ($B = .683$) implies that for every one-unit increase in teachers' utilization of AI-assisted formative assessment, pupils' learning outcomes increase by 0.683 units on average.

Discussion of Findings

The finding in regards to Research Question 1 reveals that teachers' utilization of AI-assisted formative assessment practices in primary schools in Benue State is low. This suggests that although artificial intelligence tools are increasingly recognized as valuable for enhancing formative assessment processes, their practical integration into classroom assessment practices remains limited among primary school teachers in the study area. In relation to the research question, the result indicates that the expected pedagogical shift toward AI-supported formative assessment has not yet been substantially achieved within the sampled schools.

This finding aligns with earlier evidence that highlights persistent low levels of educational technology integration in developing contexts, particularly where teachers face challenges of limited digital literacy, inadequate infrastructure, and insufficient institutional support (Ertmer & Ottenbreit-Leftwich, 2010; UNESCO, 2023). Similarly, research on technology adoption in education has consistently shown that teachers' pedagogical beliefs and lack of confidence in digital tools significantly constrain effective classroom integration of emerging technologies (Teo, 2011). The low utilization observed in this study may therefore be attributed to limited exposure to AI tools, inadequate training opportunities, and the absence of supportive policy frameworks that encourage classroom-level innovation. Educationally, this finding implies that pupils may not be fully benefiting from the diagnostic, adaptive, and feedback-enhancing potentials of AI-assisted formative assessment, thereby limiting improvements in personalized learning and instructional responsiveness. Consequently, there is a need for targeted professional development programmes, improved ICT infrastructure, and policy interventions that foster teacher readiness for AI integration. Overall, this finding underscores the broader objective of the study, which is to examine how artificial intelligence can be meaningfully integrated to enhance teaching and learning effectiveness in Nigerian primary schools.

Secondly, the finding of this study reveals a strong positive relationship between teachers' use of AI-assisted formative assessment and pupils' learning outcomes. This implies that as teachers increasingly integrate AI-supported formative assessment practices into classroom instruction, pupils tend to demonstrate improved learning outcomes in terms of academic achievement, engagement, and instructional responsiveness. In relation to the research question, the result suggests that AI-assisted formative assessment is not only relevant but also

meaningfully associated with enhanced learning experiences in primary schools in Benue State.

This finding is consistent with established empirical evidence that formative assessment, when supported by digital tools, significantly enhances student learning through timely feedback, adaptive instruction, and continuous monitoring of progress (Black & Wiliam, 2009; Hattie & Timperley, 2007). It also aligns with research indicating that educational technologies, including AI-based systems, can improve learning outcomes by personalizing instruction and supporting data-driven pedagogical decisions (Zawacki-Richter et al., 2019). The positive relationship observed may be explained by the fact that AI-assisted formative assessment provides immediate feedback, identifies learning gaps in real time, and enables teachers to adjust instruction to meet learners' needs more effectively. From a theoretical perspective, this finding is supported by constructivist learning theory, which emphasizes active learner engagement and continuous feedback as central to knowledge construction. Educationally, the implication is that strengthening teachers' capacity to use AI-driven formative assessment tools could significantly enhance pupils' learning outcomes, particularly in foundational education. Overall, this finding reinforces the study's objective of examining how AI integration can improve teaching and learning effectiveness in primary schools in Benue State.

The third finding of this study reveals that teachers' utilization of AI-assisted formative assessment significantly predicts pupils' learning outcomes in primary schools in Benue State. This indicates that AI-supported formative assessment is not merely associated with learning outcomes but also serves as a strong explanatory factor for variations in pupils' academic performance and related learning indicators. In relation to the research question, the result suggests that improvements in the

use of AI-assisted formative assessment are likely to yield substantial improvements in pupils' learning outcomes, thereby underscoring its predictive importance in the instructional process.

This finding is consistent with empirical literature which demonstrates that formative assessment, particularly when enhanced by digital technologies, exerts a strong influence on student learning by enabling continuous feedback, adaptive instruction, and evidence-based teaching decisions (Black & Wiliam, 2009; Hattie & Timperley, 2007). It also aligns with research on educational technology integration, which shows that technology-enabled assessment systems can significantly improve learning outcomes by personalizing instruction and closing learning gaps in real time (Zawacki-Richter et al., 2019). The substantial predictive power observed in this study may be explained by the capacity of AI tools to provide immediate diagnostic feedback, support individualized learning pathways, and enhance teachers' instructional responsiveness. From a theoretical standpoint, constructivist learning theory supports this outcome, as learners benefit most when instruction is adaptive, interactive, and feedback-driven. Educationally, the implication is that systematic integration of AI-assisted formative assessment could serve as a transformative strategy for improving foundational learning outcomes in primary education. Overall, the finding reinforces the central objective of the study, which is to examine how artificial intelligence integration can enhance teaching and learning effectiveness in primary schools in Benue State.

Conclusion

This study examined the influence of artificial intelligence–assisted formative assessment on pupils' learning outcomes in primary schools in Benue State. The findings reveal a generally low level of teachers' utilization of AI-assisted formative assessment practices, despite evidence of its strong

positive relationship with pupils' learning outcomes and its substantial predictive power. In particular, AI-assisted formative assessment was shown to account for a meaningful proportion of the variance in pupils' learning outcomes, indicating that when effectively applied, it has the capacity to significantly enhance learning achievement, retention, and related academic outcomes.

The study further establishes a clear mismatch between the current level of implementation and the demonstrated educational benefits of AI-assisted formative assessment. While the statistical evidence confirms its effectiveness as a determinant of pupils' learning outcomes, its limited use suggests that pupils are not fully benefiting from its instructional and diagnostic potential. The findings therefore point to a context in which the effectiveness of AI-assisted formative assessment is well established, but its integration into classroom practice remains constrained by systemic and capacity-related challenges. Overall, the study concludes that AI-assisted formative assessment is a powerful determinant of pupils' learning outcomes in primary schools in Benue State, and that improving its utilization through teacher capacity development, improved infrastructure, and supportive educational policies is essential for enhancing primary education outcomes in the state.

Recommendations

Based on the findings in this study, the following recommendations are made:

1. The Benue State Ministry of Education and UBEC should provide regular ICT and AI training for teachers to enhance their competence in using AI-assisted formative assessment in primary schools.
2. Primary school teachers should integrate AI-assisted formative assessment tools into classroom practice to

improve pupils' learning outcomes through timely feedback and personalized instruction.

3. Government and stakeholders should invest in ICT infrastructure and develop supportive policies to ensure effective and sustained integration of AI-assisted formative assessment in primary schools.

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