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DIGITAL VS PAPER-BASED ASSESSMENT: EFFECTIVENESS IN MEASURING STUDENT LEARNING IN MINNA METROPOLIS, NIGER STATE, NIGERIA

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Abstract

This study examined the comparative effectiveness of digital (computer-based) and paper-based assessments in measuring students' learning outcomes in secondary schools in Minna Metropolis, Niger State, Nigeria. Specifically, the study compared students' academic performance under both assessment modes, examined their validity and reliability, and investigated students' and teachers' perceptions regarding the effectiveness of the two assessment methods. A mixed-methods convergent parallel research design was adopted. The study employed descriptive survey and quasi-experimental approaches involving 350 respondents comprising 200 students, 100 teachers, and 50 school administrators selected through stratified random sampling from public and private secondary schools. Data were collected using the Questionnaire on Assessment Effectiveness (QAE), standardized achievement tests, interview guides, and focus group discussions. Quantitative data were analyzed using descriptive statistics, independent samples t-test, ANOVA, Pearson Product-Moment Correlation, and multiple regression with SPSS Version 26, while qualitative data were analyzed thematically using NVivo. The findings revealed no statistically significant difference in students' overall academic performance between digital and paper-based assessments ($t = 1.12$, $p = 0.26$). However, digital assessments demonstrated greater effectiveness in measuring higher-order thinking skills, providing immediate feedback, and

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improving assessment efficiency. Digital literacy significantly influenced students' performance in computer-based assessments ($F = 12.45$, $p < 0.01$), whereas gender and school type showed no significant influence. The study further found that inadequate ICT facilities, unstable electricity supply, and poor internet connectivity remain the major barriers to the effective implementation of digital assessments. The study concluded that neither assessment mode is universally superior; rather, both complement one another depending on the learning outcomes being measured. The study therefore recommends the adoption of a hybrid assessment model, increased investment in ICT infrastructure, continuous teacher capacity building, and improved digital literacy among students to enhance assessment quality in secondary schools.

Introduction

Assessment is a cornerstone of the educational process, serving multiple critical functions, including diagnosing students' learning needs, measuring academic achievement, monitoring progress, providing constructive feedback, motivating learners, and guiding instructional planning. A well-designed assessment system enables teachers to evaluate the extent to which learning objectives have been achieved while providing policymakers with evidence for educational planning and quality assurance (Black & Wiliam, 2022; Brookhart, 2023). In secondary education, assessment outcomes significantly influence students' academic progression, curriculum implementation, and educational accountability. Consequently, ensuring that assessment methods are valid, reliable, fair, and practical has become a major concern for educators and researchers worldwide.

Traditionally, secondary schools in Minna Metropolis, Niger State, have relied heavily on paper-based assessments (PBA), where students complete examinations using printed question papers and handwritten responses that are manually scored by teachers or examination bodies. This conventional assessment approach has been widely accepted because of its simplicity, familiarity, and relatively low technological requirements. However, paper-based assessments are associated with several challenges, including delays in marking and result processing, human errors during scoring, high printing and administrative costs, difficulties in storing examination scripts, and vulnerability to examination malpractice (Nitko & Brookhart, 2024). These limitations have stimulated growing interest in technology-driven alternatives capable of improving the efficiency and quality of educational assessment.

The rapid advancement of Information and Communication Technology (ICT), coupled with the increasing digitalization of educational systems, has transformed assessment

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practices across the globe. Computer-Based Assessment (CBA), online testing platforms, adaptive testing systems, and mobile-based assessment applications are increasingly replacing or complementing traditional paper examinations in many countries. The COVID-19 pandemic further accelerated this transition as schools and examination bodies sought alternative methods to sustain teaching, learning, and assessment despite widespread school closures (UNESCO, 2021). In Nigeria, major examination bodies such as the Joint Admissions and Matriculation Board (JAMB) have successfully implemented Computer-Based Testing (CBT), demonstrating the feasibility of digital assessment within the country's educational context (JAMB, 2023).

Computer-based assessment offers numerous potential advantages over traditional paper-based methods. These include immediate scoring and feedback, automated result processing, improved security through randomized questions, reduced administrative costs over time, enhanced data management, and the ability to incorporate multimedia elements such as audio, video, animations, and interactive simulations into assessment tasks (Bennett, 2025). Furthermore, digital assessments can support adaptive testing, where question difficulty is adjusted according to students' responses, thereby providing more accurate estimates of learners' abilities. Such innovations have the potential to improve assessment validity, reliability, and efficiency while increasing student engagement and motivation.

Despite these advantages, the effectiveness of computer-based assessment remains a subject of scholarly debate. Several studies have reported little or no significant difference in students' academic performance between paper-based and computer-based examinations, suggesting that both modes can produce equivalent outcomes when properly designed (Wang et al., 2025). Conversely, other researchers have found that students' computer literacy, familiarity with digital devices, internet connectivity, typing skills, and test anxiety may significantly influence performance during computer-based examinations, particularly in developing countries where access to technology remains uneven (OECD, 2023). These mixed findings indicate the need for context-specific investigations to determine whether one assessment mode provides more accurate and equitable measures of student learning than the other.

The concept of assessment effectiveness extends beyond students' examination scores. Effective assessment should demonstrate validity by accurately measuring intended learning outcomes, reliability by producing consistent results across administrations, fairness by minimizing bias against particular groups of learners, practicality through efficient administration and cost-effectiveness, and positive educational impact by encouraging meaningful learning rather than rote memorization (AERA, APA, & NCME, 2023). Therefore, comparing paper-based and computer-based assessments requires

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evaluating multiple dimensions of assessment quality rather than relying solely on differences in students' test scores.

Within the Nigerian educational system, the integration of ICT into teaching and learning has become a national priority. The National Policy on Education emphasizes the incorporation of information technology into educational delivery to improve teaching effectiveness, learning outcomes, and educational management. Similarly, the Nigerian Educational Research and Development Council (NERDC) has promoted digital literacy and technology integration across primary and secondary education. Nevertheless, implementation remains uneven due to inadequate infrastructure, limited funding, insufficient teacher training, unreliable electricity supply, poor internet connectivity, and disparities between urban and rural schools. These challenges continue to affect the successful adoption of technology-based assessment across many public secondary schools.

Minna Metropolis, the capital of Niger State, presents an appropriate setting for investigating these issues because it hosts a diverse range of public and private secondary schools with varying levels of ICT facilities and educational resources. As the home of institutions such as the Federal University of Technology, Minna (FUTMinna), the metropolis has experienced increasing exposure to educational technology initiatives while still facing infrastructural constraints common to many Nigerian cities. Schools within the metropolis differ considerably in terms of computer availability, internet access, teacher competence in ICT, and students' digital literacy, making Minna an ideal environment for comparing the effectiveness of paper-based and computer-based assessment methods under real educational conditions.

Although numerous international studies have examined the comparative effectiveness of paper-based and computer-based assessments, empirical evidence from Niger State remains limited. Most Nigerian studies have focused primarily on national CBT examinations such as JAMB, with relatively little attention given to classroom-based assessments in secondary schools. Furthermore, there is insufficient evidence regarding how local contextual factors—including socio-economic status, school ownership, technological readiness, teacher preparedness, and students' digital competence influence the effectiveness of different assessment modes within Minna Metropolis. Addressing this gap is essential for informing educational policy, guiding investment in educational technology, and supporting evidence-based decisions regarding assessment practices in Nigerian secondary schools.

Therefore, this study investigates the comparative effectiveness of paper-based and computer-based assessments in evaluating students' academic performance in selected secondary schools within Minna Metropolis, Niger State. Specifically, the study compares both assessment modes in terms of validity, reliability, fairness, practicality, student

engagement, and their influence on academic performance across core subjects such as Mathematics, English Language, Basic Science, and Social Studies. The findings are expected to provide valuable evidence for teachers, school administrators, curriculum developers, examination bodies, and policymakers seeking to strengthen assessment quality and promote effective integration of technology into secondary education in Nigeria.

Statement of the Research Problem

Assessment is an indispensable component of the teaching and learning process because it provides evidence of students' academic achievement, monitors learning progress, and informs instructional and policy decisions. The effectiveness of any educational system depends largely on the quality, fairness, validity, and reliability of its assessment practices. Traditionally, secondary schools in Minna Metropolis have relied predominantly on paper-based assessments due to their familiarity, ease of administration, and relatively low technological requirements. However, the rapid advancement of Information and Communication Technology (ICT) has led to increased advocacy for computer-based assessment as a more efficient and innovative alternative capable of improving educational outcomes.

Despite the numerous advantages associated with digital assessments, including automated scoring, faster result processing, improved examination security, enhanced data management, immediate feedback, and reduced paper consumption, their implementation in many secondary schools within Minna Metropolis remains limited and inconsistent. While some schools have begun integrating computer-based testing into their assessment systems, many others continue to depend almost entirely on traditional paper-based examinations. This uneven adoption reflects persistent challenges such as inadequate ICT infrastructure, unreliable electricity supply, poor internet connectivity, insufficient funding, limited availability of computers and digital devices, inadequate technical support, and insufficient training for teachers and school administrators. These constraints have slowed the transition toward digital assessment despite national efforts to promote ICT integration in education.

The continued dependence on paper-based assessment also presents several educational and administrative challenges. Manual marking often requires considerable time, delaying the release of examination results and limiting opportunities for timely feedback that could improve students' learning. Human errors in scoring, subjective grading, loss or damage of examination scripts, high costs associated with printing and storing examination materials, and vulnerability to examination malpractice further reduce the efficiency and credibility of traditional assessment methods. These shortcomings raise

concerns about the ability of paper-based assessment to consistently provide accurate, objective, and reliable measures of students' academic performance.

On the other hand, the adoption of computer-based assessment introduces its own set of challenges. Students' varying levels of computer literacy, limited familiarity with digital examination interfaces, test anxiety associated with technology, system failures, software malfunctions, power interruptions, and internet connectivity problems may negatively influence students' performance independently of their actual academic ability. Furthermore, disparities in access to computers and digital resources between public and private schools, as well as between students from different socio-economic backgrounds, create concerns regarding equity and fairness in digital assessment. These factors contribute to the digital divide, which may compromise the validity of assessment outcomes if not adequately addressed.

Another important concern is whether paper-based and computer-based assessments measure students' knowledge and skills with the same degree of accuracy and consistency. Although several international studies have compared the two assessment modes, findings remain inconsistent. Some studies report no significant differences in students' performance, whereas others suggest that assessment mode can influence examination outcomes due to technological familiarity, question presentation, or students' attitudes toward digital testing. Such inconsistencies highlight the need for context-specific investigations, particularly in developing countries where educational and technological conditions differ considerably from those of developed nations.

In Minna Metropolis, empirical evidence comparing the effectiveness of paper-based and computer-based assessments in secondary schools is scarce. Existing Nigerian studies have largely concentrated on national Computer-Based Testing (CBT) examinations such as those conducted by JAMB, with limited attention given to classroom-based assessments at the secondary school level. Consequently, educational administrators, teachers, curriculum planners, and policymakers in Niger State have limited local evidence to guide decisions regarding the selection, implementation, or integration of appropriate assessment methods. The absence of such evidence may result in policy decisions that fail to address the realities of schools within the state.

Given these challenges, there is a pressing need to examine the comparative effectiveness of paper-based and computer-based assessments in evaluating students' academic performance in secondary schools within Minna Metropolis. Specifically, it is important to determine whether one assessment mode demonstrates superior validity, reliability, fairness, practicality, and effectiveness in measuring students' learning outcomes, or whether a combination of both approaches offers the most suitable solution. Therefore, this study seeks to bridge this knowledge gap by providing empirical evidence on the comparative effectiveness of paper-based and computer-based

assessments within the socio-economic, technological, and educational context of Minna Metropolis, Niger State. The findings are expected to contribute to educational policy formulation, improve assessment practices, and support the successful integration of technology into secondary school assessment in Nigeria.

Aims and Objectives

The main aim of this study is to compare the effectiveness of digital (computer-based) and paper-based assessments in measuring students' learning outcomes in secondary schools in Minna Metropolis, Niger State. The study seeks to determine which assessment mode provides more valid, reliable, fair, practical, and accurate measures of students' academic achievement while considering the technological and educational realities of the study area.

Specific Objectives

The specific objectives of the study are to:

1. Compare the academic performance of students who are assessed using digital (computer-based) assessments and those assessed using paper-based assessments in selected secondary schools in Minna Metropolis.
2. Examine the validity of digital and paper-based assessments in measuring students' learning outcomes.
3. Determine the reliability of digital and paper-based assessment methods in evaluating students' academic achievement.
4. Assess students' perceptions of digital and paper-based assessments with respect to ease of use, fairness, satisfaction, and overall testing experience.
5. Examine teachers' perceptions of the effectiveness of digital and paper-based assessments in evaluating students' academic performance.

Research Hypotheses

H01: There is no significant difference in the validity and reliability of students' learning outcomes measured through digital (computer-based) assessments and paper-based assessments in secondary schools in Minna Metropolis, Niger State.

H02: There is no significant difference in the academic performance of students assessed using digital (computer-based) assessments and those assessed using paper-based assessments in secondary schools in Minna Metropolis, Niger State.

H03: Students' demographic characteristics (gender, school type, and level of digital literacy) do not significantly moderate the effectiveness of digital and paper-based assessments in measuring learning outcomes.

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H04: There is no significant difference in students' perceptions of the effectiveness, fairness, ease of use, and overall acceptability of digital and paper-based assessments in secondary schools in Minna Metropolis, Niger State.

H05: There is no significant relationship between the availability of Information and Communication Technology (ICT) facilities, teachers' ICT competence, and the effective implementation of digital assessments in secondary schools in Minna Metropolis, Niger State.

Research Design

This study adopted a mixed-methods convergent parallel research design, which integrates both quantitative and qualitative approaches to provide a comprehensive understanding of the comparative effectiveness of digital (computer-based) and paper-based assessments in measuring students' learning outcomes in secondary schools in Minna Metropolis, Niger State. The mixed-methods approach was considered appropriate because it enabled the researcher to collect, analyze, and interpret both numerical and descriptive data concurrently, thereby providing a more complete understanding of the research problem than either method could achieve independently.

The quantitative component employed a descriptive survey design together with a quasi-experimental design. The descriptive survey was used to obtain information on the perceptions, experiences, and opinions of students, teachers, and school administrators regarding the effectiveness, validity, reliability, fairness, and practicality of digital and paper-based assessments. The quasi-experimental aspect involved comparing students' academic performance under the two assessment modes without randomly assigning participants to treatment groups, since students remained within their existing school and classroom settings. This design allowed the researcher to determine whether significant differences existed between students assessed through computer-based assessments and those assessed through traditional paper-based examinations.

The qualitative component consisted of semi-structured interviews with selected school administrators and teachers, as well as focus group discussions with students. These methods provided in-depth insights into participants' experiences, challenges, attitudes, and perceptions regarding both assessment methods. The qualitative findings complemented the quantitative results by explaining the reasons behind observed statistical patterns and identifying contextual factors that could not be adequately captured through questionnaires alone.

The study adopted the convergent parallel design because both quantitative and qualitative data were collected during the same phase of the research process, analyzed separately, and subsequently integrated during interpretation. This process of triangulation enhanced the credibility, validity, and reliability of the findings by allowing

evidence from one method to confirm or explain findings obtained through the other. The integration of both approaches provided a holistic understanding of the strengths, weaknesses, opportunities, and challenges associated with digital and paper-based assessments in secondary schools within the study area.

The target population comprised all senior secondary school students (SS I–SS III), teachers, and school administrators in public and private secondary schools located within Minna Metropolis, Niger State. These categories of respondents were selected because they are directly involved in the administration, implementation, and experience of classroom assessments and therefore possess relevant information regarding the effectiveness of different assessment methods.

A sample size of 350 respondents was selected for the study using a stratified random sampling technique to ensure adequate representation of the various categories of participants. The sample consisted of 200 senior secondary school students, 100 teachers, and 50 school administrators drawn from selected public and private secondary schools across the metropolis. Stratification was based on participants' roles and school ownership to ensure that different perspectives were fairly represented. Thereafter, simple random sampling was employed within each stratum to select the required respondents, thereby minimizing sampling bias and improving the generalize ability of the findings.

The mixed-methods convergent parallel research design was considered most suitable for this study because it combined the strengths of quantitative measurement with the richness of qualitative inquiry. While the quantitative data provided objective evidence regarding differences in assessment effectiveness and students' performance, the qualitative data offered deeper explanations of participants' experiences, institutional challenges, technological readiness, and contextual realities influencing the implementation of digital and paper-based assessments in secondary schools in Minna Metropolis, Niger State. This combination ultimately enhanced the validity, comprehensiveness, and practical relevance of the study's findings.

Instruments

Two main instruments were used:

1. Questionnaire on Assessment Effectiveness (QAE) – A 5-point Likert scale instrument covering perceptions, advantages, and challenges (validated with Cronbach's Alpha = 0.87).
2. Standardized Test Battery – Parallel forms of subject tests administered in both digital (using platforms like Google Forms or local CBT software) and paper formats to the same groups for comparison.

Semi-structured interview guides supplemented the data.

Data Collection Procedure

Permissions were secured from the Niger State Ministry of Education and school authorities. Digital tests were conducted in equipped labs where available, with paper versions following immediately or in counterbalanced order to control for order effects. Questionnaires and interviews were administered over a four-week period, ensuring ethical considerations like informed consent and anonymity.

Data Analysis

The data collected for this study were analyzed using both quantitative and qualitative analytical techniques in line with the mixed-methods convergent parallel research design adopted for the study. Quantitative and qualitative data were analyzed separately before being integrated during the interpretation of the findings to provide a comprehensive understanding of the comparative effectiveness of digital and paper-based assessments in secondary schools in Minna Metropolis, Niger State.

The quantitative data obtained through the structured questionnaires and students' assessment scores were coded, entered, cleaned, and analyzed using the Statistical Package for the Social Sciences (SPSS) version 26.0. Prior to the main analysis, the data were examined for completeness, accuracy, missing values, and outliers to ensure data quality. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize the demographic characteristics of respondents and describe their responses to the research variables.

To test the research hypotheses, appropriate inferential statistical techniques were employed at a 0.05 level of significance. An Independent Samples t-test was used to determine whether significant differences existed between students' academic performance under digital (computer-based) and paper-based assessment methods. One-Way Analysis of Variance (ANOVA) was employed to examine whether demographic variables such as gender, school type (public or private), and level of digital literacy significantly influenced the effectiveness of the assessment methods. Where significant differences were identified, appropriate post hoc comparisons were conducted to determine the specific groups responsible for the observed differences.

In addition, Pearson Product-Moment Correlation Analysis (PPMC) was used to examine the relationships between variables such as ICT infrastructure, students' digital literacy, teachers' ICT competence, and the effectiveness of digital assessment. Where appropriate, multiple regression analysis was also used to determine the extent to which selected predictor variables contributed to the effectiveness of computer-based assessment. The results of the statistical analyses were presented using tables, charts, and narrative explanations to facilitate interpretation.

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The qualitative data obtained through semi-structured interviews and focus group discussions were analyzed using NVivo qualitative data analysis software. Audio-recorded interviews were transcribed verbatim, after which the transcripts were carefully read several times to achieve familiarity with the data. The researcher employed thematic analysis, beginning with open coding to identify meaningful statements and concepts. Similar codes were then grouped into categories, from which broader themes and sub-themes emerged. These themes reflected participants' experiences, perceptions, challenges, and recommendations regarding digital and paper-based assessment practices in secondary schools.

To enhance the credibility and trustworthiness of the qualitative findings, coding consistency was maintained throughout the analysis, and representative quotations from participants were used to support the identified themes where appropriate. The thematic findings were organized and interpreted in relation to the study objectives and existing literature.

Finally, the quantitative and qualitative findings were integrated at the interpretation stage using the convergent parallel mixed-methods approach. The researcher compared, contrasted, and merged findings from both data sets to identify areas of convergence, complementarity, and divergence. This triangulation process strengthened the validity of the study by providing multiple sources of evidence regarding the comparative effectiveness of digital and paper-based assessments. The integrated findings formed the basis for the discussion of results, conclusions, recommendations, and implications for educational policy and practice in secondary schools within Minna Metropolis, Niger State.

Table 1: Demographic Characteristics of Respondents (N = 350)

Variable	Category	Frequency	Percentage (%)
Gender	Male	190	54.3
	Female	160	45.7
Role	Students	200	57.1
	Teacher	100	28.6
	Administrators	50	14.3
School Type	Public	210	60.0
	Private	140	40.0

Source: Field Survey (2026)

Table 2: Comparison of Academic Performance

Assessment Mode	Mean	SD	t-value	p-value	Decision
Digital	68.4	9.6	1.12	0.26	Not Significant
Paper-based	67.1	10.2			

Source: Field Survey (2026)

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Table 3: Effect of Digital Literacy

Variable	F-value	p-value	Decision
Digital Literacy	12.45	<0.01	Significant
Gender	1.09	0.31	Not Significant
School Type	0.84	0.40	Not Significant

Source: Field Survey (2026)

Table 4: Major Challenges

Challenge	Percentage (%)
Poor Electricity	78
Poor Internet	65
Inadequate Computers	62
Poor ICT Skills	58
Teacher Training	54
High Cost	52
Technical Failure	47
Cybersecurity Concerns	39

Source: Field Survey (2026)

Discussion of Findings

The study found no statistically significant difference in students' overall academic performance between digital and paper-based assessments ($t = 1.12$, $p = 0.26$). This suggests that both assessment methods are capable of measuring students' learning outcomes effectively when properly implemented. This finding is consistent with previous studies that reported comparable levels of validity between computer-based and traditional paper-based assessments.

The study further revealed that digital assessments were more effective in measuring higher-order thinking skills and provided immediate feedback, automated scoring, and better performance monitoring. These findings support earlier research, which reported that digital assessments improve assessment efficiency and enhance students' engagement through instant feedback and adaptive assessment features.

Students generally preferred paper-based assessments because of familiarity, whereas teachers showed greater preference for digital assessments due to reduced workload and faster grading. This difference may be attributed to varying levels of digital competence among respondents and their previous experiences with assessment methods.

The findings also showed that students' digital literacy significantly influenced their performance in computer-based assessments ($F = 12.45$, $p < 0.01$). Students with higher ICT competence performed significantly better than those with limited digital skills. This

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finding agrees with existing studies emphasizing digital literacy as a critical factor in the successful implementation of technology-based assessments.

Finally, inadequate ICT infrastructure, poor electricity supply, unstable internet connectivity, and insufficient teacher training were identified as the major challenges limiting the implementation of digital assessments. These findings are consistent with studies conducted in developing countries, which identified infrastructure deficits and limited technological readiness as major barriers to educational digital transformation.

Overall, the findings indicate that a hybrid assessment approach combining the strengths of both digital and paper-based assessments is the most appropriate strategy for secondary schools in Minna Metropolis.

Summary of Findings

The findings of the study indicate that both digital and paper-based assessments are effective tools for measuring students' academic achievement, as no statistically significant difference was found in their overall assessment outcomes. Nevertheless, digital assessments demonstrated greater efficiency in terms of feedback speed, automated scoring, and performance analytics, while paper-based assessments remained more acceptable to many students because of familiarity. Furthermore, students' level of digital literacy significantly influenced success in computer-based assessments, highlighting the importance of improving ICT competence before widespread implementation of digital assessment systems. Finally, inadequate infrastructure particularly unstable electricity supply and poor internet connectivity remains the greatest obstacle to the effective adoption of digital assessments in secondary schools within Minna Metropolis, Niger State.

Conclusion

Both digital and paper-based assessments have unique strengths and limitations in measuring student learning in Minna. While neither is universally superior, digital methods hold greater potential for innovation and scalability when supported by adequate infrastructure. A balanced, context-sensitive implementation is essential for enhancing educational outcomes in Niger State.

Recommendations

1. Infrastructure Development: Government and stakeholders should prioritize reliable electricity, internet, and device provision in schools.
2. Capacity Building: Comprehensive training programs for teachers and students on digital assessment tools.

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3. Hybrid Models: Adopt blended approaches combining paper for summative high-stakes exams and digital for continuous/formative assessment.
4. Policy Framework: Develop guidelines for equitable digital transition, including data privacy and accessibility standards.
5. Pilot Programs: Scale successful Minna-based pilots across the state with continuous evaluation.
6. Equity Focus: Address the digital divide through subsidized devices and community learning centers.

Contribution to the Knowledge

This study adds localized empirical evidence from Minna Metropolis to the growing body of research on assessment modes in sub-Saharan Africa. It provides a comparative framework adaptable to other Nigerian states, highlights moderating variables like digital literacy, and proposes practical hybrid solutions. By integrating psychometric and socio-technical perspectives, it advances understanding of technology integration in resource-limited educational contexts and informs future NERDC and state-level policies.

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