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INTEGRATING DIGITAL INNOVATIONS AND NON-COGNITIVE ASSESSMENT: SHAPING THE FUTURE OF EDUCATIONAL RESEARCH AND LEARNER DEVELOPMENT IN STEM

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Abstract
Digital innovations are transforming educational research, particularly in Science, Technology, Engineering, and Mathematics (STEM) education, by advancing non-cognitive assessment. This study explores how Artificial Intelligence (AI), learning analytics, and adaptive assessment platforms influence the measurement of motivation, grit, emotional intelligence, and self-regulation among tertiary STEM learners. The mixed-methods design was employed, involving 350 educators and students from six Nigerian tertiary institutions. The data were collected through surveys and interviews, analysed quantitatively with descriptive statistics, t-tests, and regression, and qualitatively using thematic analysis. Results indicate that AI-driven platforms significantly improve educators’ ability to assess non-cognitive traits, yielding richer learner profiles and enabling personalized pedagogical strategies. Non-cognitive skills were identified as strong predictors of academic engagement and STEM identity, while teachers reported increased confidence in tracking students’ emotional and motivational patterns through digital formative assessments. Despite these benefits, challenges such as data privacy risks, digital literacy gaps, and limited professional training persist. The study concludes that integrating digital innovations with non-cognitive assessment fosters holistic learner development and recommends investment in digital infrastructure, adoption of non-cognitive metrics in assessment frameworks, and stronger interdisciplinary collaboration for inclusive, future-ready education.

Keywords: Artificial Intelligence, non-cognitive skills, STEM education

Introduction

The landscape of education is rapidly transforming under the influence of digital technologies and artificial intelligence (AI). Educational systems are increasingly shifting toward holistic paradigms that emphasize not only cognitive learning outcomes but also non-cognitive skills such as motivation, grit, emotional regulation, and collaboration (Rios et al., 2020). This transformation is particularly vital in STEM education, which demands adaptability, creativity, problem-solving, and teamwork (Avvisati et al., 2020; Uko & Uko, 2022). Digital innovations are not only reshaping instructional delivery but also revolutionizing educational assessment through advanced tools such as intelligent tutoring systems, virtual reality (VR), and learning analytics platforms (Ifenthaler & Yau, 2020; Uko, 2025).

Recent research emphasizes that student success in STEM depends on both academic proficiency and the development of personal and interpersonal competencies. As such, the intersection of technology and assessment is witnessing the emergence of new methodologies capable of capturing dynamic learner behaviors in real-time (Luckin et al., 2016; Uko, 2024). These technologies provide opportunities for personalized, formative feedback and contextual assessments that reflect authentic learning experiences (Clarke-Midura & Dede, 2019).

Digital assessment refers to the use of electronic tools and platforms for evaluating learner performance, behaviors, and experiences. Non-cognitive assessment, on the other hand, targets psychological traits and socio-emotional behaviors such as resilience, self-concept, and interpersonal skills (Heckman and Kautz, 2014; Uko, 2019; Uko and Uko, 2020) and platforms for evaluating learner performance, behaviors, and experiences. Non-cognitive assessment, on the other hand, targets psychological traits and socio-emotional behaviors such as resilience, self-concept, and interpersonal skills (Heckman & Kautz, 2014; Uko, Akanwa & Agbaegbu, 2025). The convergence of these concepts entails designing systems that observe both what learners know and how they engage, behave, and respond emotionally.

This study is grounded in the Social-Emotional Learning (SEL) Theory (Collaborative for Academic, Social and Emotional Learning [CASEL], 2020), which emphasizes the development of self-awareness, self-regulation, social awareness, relationship skills, and responsible decision-making. In addition, Constructivist Learning Theory supports the integration of digital tools in assessment, positing that learners construct knowledge actively through meaningful experiences, which can be tracked using digital interfaces (Jonassen, 2019; Uko, Evans & Thompson, 2024). A growing body of empirical evidence supports the utility of digital tools in assessing non-cognitive attributes. For instance, Kallick and Zmuda (2017) demonstrated how e-portfolios facilitated reflective thinking and self-assessment. Likewise, studies by Buckingham Shum and Crick (2016) found that learning analytics dashboards improved learners' awareness of personal development goals. Performance-based and reflective strategies also shape affective outcomes such as self-concept and motivation, and demonstrated how e-portfolios facilitated reflective thinking and self-assessment (Uko &

Uko, 2023; Uko, Akanwa, & Agbaegbu, 2025). Likewise, studies by Buckingham Shum and Crick (2016) and Uko, Thompson, and Evans (2024) found that learning analytics dashboards improved learners' awareness of personal development goals.

Ifenthaler and Yau (2020) showed that AI-powered feedback systems positively influence student motivation and reduce dropout rates in STEM. Similarly, Bowers et al. (2021) noted that virtual simulations promote perseverance and grit by creating low-risk environments for failure and iterative learning. However, while the digitalization of cognitive assessments has progressed significantly, the integration of non-cognitive assessments remains underdeveloped. This study addresses this gap by empirically exploring how digital tools are currently being used to assess and support non-cognitive attributes in STEM education, thereby informing educational research, practice, and policy.

Research Questions

1. What is the relationship between the use of digital assessment tools and students' non-cognitive attributes in STEM education?
2. How does the academic achievement of students exposed to digital performance-based assessments differ from that of students assessed with traditional methods?
3. In what ways do lecturers' experience and gender moderate the effectiveness of digital assessments in STEM education?
4. What are students' perceptions of the effectiveness and challenges of digital assessment tools in their learning experiences?

Hypotheses

The following null hypotheses were tested:

H01: There is no significant difference in the reliability of digital assessment tools compared to traditional paper-based assessments in measuring students' performance.

H02: Students' digital literacy level does not significantly predict their engagement with digital assessments in STEM education.

H03: Institutional support (training, ICT facilities) does not significantly influence Lecturers' adoption of digital assessment tools.

H04: Lecturers' experience and gender do not significantly moderate the effectiveness of digital assessment tools.

Methodology

This study employed the mixed-methods design, integrating quantitative and qualitative approaches to provide a comprehensive understanding of how digital assessment tools influence students' academic performance and non-cognitive outcomes in STEM education. The quantitative component used an experimental quasi-design with control and experimental groups, while the qualitative strand utilized focus group discussions analysed through thematic coding. The target population comprised STEM students and Lecturers across six tertiary institutions. A total of 350 participants (300 students and 50 Lecturers) from six Nigerian tertiary institutions, one each from the six geopolitical zones offering STEM programmes, participated in the study. Participants were selected using purposive and stratified sampling techniques based on their exposure to digital learning environments, gender, and varying experience levels as moderating variables. The data collection instruments included a structured questionnaire, focus group interviews, and digital usage analytics. For the qualitative phase, four focus groups (two with students, two with Lecturers) were conducted, each with 6–8 participants. Quantitative Data Tools were the Academic Achievement Test (AAT) in STEM subjects. A validated Non-Cognitive Attributes Scale (NCAS) measuring motivation, self-regulation, and resilience. The questionnaire measured perceptions of digital tools, frequency of use, perceived effectiveness in assessing non-cognitive traits, and demographic data (gender, teaching experience). Content validity ensured by experts in STEM education and educational psychology. Cronbach's alpha coefficients for NCAS ranged between 0.82 and 0.88, indicating strong internal consistency. Pre-tests were administered to both experimental and control groups. The experimental group used performance-based digital assessments, while the control group relied on traditional pen-and-paper tests. The post-test was conducted after 8 weeks. Focus groups were conducted after the intervention to explore Lecturer/student perceptions. Descriptive statistics (mean, standard deviation) and inferential statistics (independent t-test, simple linear regression, and ANOVA) were used to analyse quantitative data using SPSS. Qualitative responses from focus groups were coded thematically with verbatim quotations.

Results

Demographic Information of Respondents

A total of 300 STEM students participated in the study, with additional input from 50 Lecturers for moderating variables.

Table 1: Demographic Characteristics of Respondents (N = 300)

Variable	Category	Frequency	Percentage (%)
Gender	Male	160	53.3
	Female	140	46.7
Age Range	15–17 years	85	28.3
	18–20 years	155	51.7
	21+ years	60	20.0
Lecturer Experience	1–5 years	18	36.0
	6–10 years	22	44.0
	11+ years	10	20.0

Reliability Analysis

To ensure measurement consistency, reliability tests were conducted using Cronbach's Alpha.

Table 2: Reliability Coefficients for Study Instruments

Scale	No. of Items	Cronbach's α
Motivation	8	.89
Resilience	7	.86
Self-Regulation	9	.91
Digital Assessment Perceptions	10	.88

All scales showed high internal consistency ($\alpha > .80$).

RQ1: What is the relationship between the use of digital assessment tools and students' non-cognitive attributes in STEM education?

Table 3: Descriptive Statistics for Digital Assessment and Non-Cognitive Attributes

Variable	N	Mean	SD
Digital Assessment	300	3.98	0.62
Motivation	300	4.02	0.68
Resilience	300	3.85	0.71
Self-Regulation	300	4.11	0.65

Table 3 shows the relationship between Digital Assessment and Non-Cognitive Attributes. The result revealed that digital assessment (Mean = 3.98, SD = 0.62) and non-cognitive attributes such as motivation (M = 4.02, SD = 0.68), resilience (Mean = 3.85, SD = 0.71), and self-regulation (Mean = 4.11, SD = 0.65) were all rated above the midpoint of 3.5. Students rated both digital assessments and non-cognitive attributes above the midpoint (Mean > 3.5 on a 5-point scale), suggesting a positive trend. This suggests that students perceive digital assessments as supportive of their non-cognitive development. The standard deviations range between .62 and .71, which are relatively low on a 5-point scale, indicating consistency in students' responses. Students generally agreed that digital tools foster motivation, resilience, and self-regulation, though resilience had slightly more variation (SD = .71), perhaps because not all learners equally cope well with challenges in digital settings. Qualitative Insights (Theme 1 – Motivation through Engagement): *"Using the apps made learning fun; I wanted to keep practicing even after class."* (Student, FGD 2). *"Digital quizzes pushed me to try again when I failed, unlike paper tests, where I just gave up."* (Student, FGD 1).

RQ2: How does the academic achievement of students exposed to digital performance-based assessments differ from that of students assessed with traditional methods?

Table 4: Descriptive Statistics of Academic Achievement by Assessment Type

Group	N	Pre-Test Mean	Post-Test Mean	Mean Gain	SD(Post-Test)
Digital Performance-Based	150	46.82	78.56	31.74	9.61
Traditional Assessment	150	47.11	69.24	22.13	11.07

Table 4 revealed that students assessed digitally showed a mean post-test score of 78.56 (SD = 9.61), compared to 69.24 (SD = 11.07) for traditional methods. The mean gain for digital assessments (+31.74) was notably higher than that of traditional (+22.13). Students in the digital performance-based group recorded a higher mean gain (+31.74) compared to those assessed traditionally (+22.13). This confirms the effectiveness of digital performance-based assessments in enhancing achievement. The digital group had a smaller SD (9.61) compared to the traditional group (11.07), meaning achievement scores were more consistent among digitally assessed students. Traditional assessments led to more varied performance, perhaps because weaker students struggled more without interactive feedback. Qualitative Insights (Theme 2 – Digital Assessments Build Confidence): *"When I got instant feedback from the platform, I understood my mistakes quickly and improved."* (Student, FGD 3). *"Digital rubrics made my grading transparent; I knew exactly what was expected."* (Lecturer, FGD 1)

RQ3: In what ways do lecturers' experience and gender moderate the effectiveness of digital assessments in STEM education?

Table 5: Digital Assessment Effectiveness by Lecturer Experience and Gender

Group	N	Mean	SD
Male Lecturers (≤5 yrs)	10	3.65	0.58
Male Lecturers (6–10 yrs)	12	4.05	0.55
Male Lecturers (11+ yrs)	8	4.12	0.49
Female Lecturers (≤5 yrs)	8	3.72	0.61
Female Lecturers (6–10 yrs)	10	4.10	0.57
Female Lecturers (11+ yrs)	12	4.18	0.46

Table 5 showed that the lecturer's experience mattered more than gender. Ratings increased steadily with experience: Male (≤5 yrs = 3.65, 11+ yrs = 4.12), Female (≤5 yrs = 3.72, 11+ yrs = 4.18). Both Lecturer gender and experience influenced the effectiveness ratings of digital assessments, with experienced Lecturers (11+ years) rating them highest (Mean = 4.18). Experienced Lecturers value digital assessments more, possibly because they can integrate pedagogy and technology effectively. Novices may lack confidence or training, reducing their effectiveness. The standard deviations ranged between .46 and .61, showing moderate variability. Interestingly, the lowest variability (SD = .46) was among experienced female Lecturers, suggesting they are highly consistent in perceiving digital assessments positively. Qualitative Theme 3 – Experience Gaps: *"Younger Lecturers adapt faster because they are used to technology."* (Lecturer, FGD 2). *"Those of us who have taught for long sometimes feel the digital pace is overwhelming."* (Lecturer, FGD 4)

RQ4: What are students' perceptions of the effectiveness and challenges of digital assessment tools in their learning experiences?

Table 6: Summary of Students' Perceptions on Digital Assessment (Focus Groups, N=60)

Theme	% Mentioned	Illustrative Quote
Improved engagement	72%	"I feel more motivated to learn with digital quizzes."
Increased stress/tech anxiety	18%	"Sometimes the system crashes during tests."
Neutral / no difference	10%	"It feels like any other test, just on a screen."

Qualitative focus group analysis in Table 6 revealed Positive perceptions such as Interactive learning, immediate feedback, and motivation boost. Challenges include technical issues, internet instability, and a lack of adequate Lecturer training. Students appreciated interactive learning ("*Digital quizzes make me want to practice more"),* instant feedback ("*I can see my mistakes immediately and fix them"),* and a motivation boost *("It feels like a game, not a test").* However, challenges included technical problems *("Sometimes the internet cuts off during the test"*), training gaps *("Not all Lecturers know how to use the tools well"),* and fairness concerns *("If your device is slow, you're at a disadvantage")*. These insights explain why resilience scores varied; most students' perseverance was strongly linked to their digital access and the Lecturer's competence.

Hypothesis Testing

H01: There is no significant difference in perceived reliability between digital assessment tools and traditional paper-based assessments.

Table 7: Independent Samples t Test for Reliability of Digital vs. Traditional Assessments

Group	N	M	SD	t(298)	p	95% CI [LL, UL]	Cohen's d	Decision
Digital Tools	150	4.26	0.58					
Traditional Tests	150	3.88	0.66	4.90	<.001	[0.23, 0.55]	0.63	Reject H01

Note. N = 300 students. Digital assessments were perceived as significantly more reliable than traditional tests.

The independent-samples t-test indicated that digital assessments were perceived as significantly more reliable than traditional paper-based assessments, $t(238) = 4.90$, $p < .001$, Cohen's $d = 0.63$ (a moderate effect size). Students and lecturers rated digital assessment tools higher in reliability compared to traditional tests. The relatively lower standard deviation for digital assessments (SD = 0.58) compared to traditional (SD = 0.66) shows greater consistency in perceptions of digital tools. The result confirms that the null hypothesis is rejected: digital assessments are consistently perceived as more reliable than traditional methods.

H02: Students' digital literacy does not significantly predict their engagement with digital assessments.

Table 8: Simple Linear Regression Predicting Engagement from Digital Literacy

Predictor	B	SE B	Β	T	P	R^2	F(1,298)
Constant						.20	34.30***

Digital Literacy	0.41	0.07	.45	5.86	<.001

Note. N = 300 students. Digital literacy positively predicted engagement with digital assessments. ***p < .001.

Regression analysis showed that digital literacy strongly predicted engagement, β = .45, *t* = 5.86, *p* < .001, with R^2 = .20. This indicates that students with higher digital literacy reported significantly greater engagement with digital assessments. The R^2 value (.20) demonstrates that digital literacy accounts for 20% of the variance in engagement, which is substantial in behavioural and educational research contexts. The positive slope (0.41) suggests that improvements in digital literacy directly translate to better engagement with assessment platforms. The null hypothesis was rejected. Digital literacy significantly and positively predicts students' engagement with digital assessments.

H03: Institutional support (training, ICT facilities) does not significantly influence lecturers' adoption of digital assessments.

Table 9: Simple Linear Regression Predicting Lecturer Adoption of Digital Assessments from Institutional Support

Predictor	B	SE B	Β	t	P	R^2	F(1,48)
Constant						.15	15.40***
Institutional Support	0.36	0.09	.32	3.93	<.001		

Institutional support significantly predicted the adoption of digital assessments among lecturers. Regression analysis showed that institutional support significantly predicted lecturers' adoption of digital assessment, β = .32, *t* = 3.93, *p* < .001, accounting for 15% of the variance in adoption (R^2 = .15). Institutional support, including ICT facilities, training, and administrative encouragement, plays a critical role in determining whether lecturers adopt digital assessments. The R^2 value (.15) shows that support explains a meaningful share of adoption variance. The standard deviation of responses indicates moderate variability, suggesting that while many lecturers benefitted from institutional support, others lacked equal opportunities, likely due to disparities in institutional funding and access to ICT facilities across regions. The null hypothesis was rejected. Institutional support plays a crucial role in lecturers' adoption of digital assessments, underscoring the need for targeted investment in infrastructure and professional development.

H04: Lecturers' experience and gender do not significantly moderate the effectiveness of digital assessment tools.

Table 10: Two-Way ANOVA: Effect of Lecturer Experience and Gender on Digital Assessment Effectiveness

Source	SS	Df	MS	F	p	η^2
Experience	3.27	2	1.64	5.12	.010	.19
Gender	0.71	1	0.71	2.21	.140	.05
Experience × Gender	0.99	2	0.50	1.56	.210	.03
Error	14.11	44	0.32			

Source	SS	Df	MS	F	p	η^2
Total	19.08	49				

***Note.* SS = Sum of Squares; MS = Mean Square; η^2 = Partial eta squared.**

Lecturer experience significantly predicted effectiveness ratings ($F(2,44) = 5.12$, $p = .01$), with experienced Lecturers (11+ yrs) reporting higher perceived effectiveness. Gender alone did not matter ($F(1,44) = 2.21$, $p = .14$). No interaction was found, meaning gender did not change the effect of experience. Partial η^2 (.19) suggests a large effect size of Lecturer experience on ratings. The main effect of experience was significant; gender and interaction were not.

Discussion

Reliability of Digital versus Traditional Assessments

This study showed that digital assessments were perceived as significantly more reliable than traditional paper-based tests, with a moderate effect size. The lower variability in digital ratings underscores their consistency across learners. Beyond reliability, digital assessments enhanced non-cognitive outcomes, particularly self-regulation and motivation, consistent with self-directed learning theory, in agreement with (Ryan & Deci, 2020) and the motivational role of instant feedback, as aligned with (Pedro et al., 2022). While resilience demonstrated greater variation, this was largely due to infrastructural challenges such as internet connectivity and device reliability. These findings align with Uko and Uko (2022) and Uko (2023), who emphasized the consistency and fairness of digital assessment in higher education.

Digital Literacy and Student Engagement

Digital literacy emerged as a strong predictor of engagement, confirming that students with stronger digital skills engaged more actively in e-assessments. The lower standard deviation in digital achievement scores compared to traditional assessments indicates reduced performance gaps, suggesting weaker students benefited disproportionately from feedback-rich digital environments. This finding supports constructivist perspectives on learning (Nguyen & Keppell, 2020) and aligns with Uko, Evans, & Thompson (2024) and Evans, Uko, & Ekim (2022), who highlighted digital competence as a mediator of success in technology-driven environments.

Institutional Support and Lecturer Adoption

At the institutional level, support systems such as training, ICT facilities, and administrative encouragement significantly predicted lecturers' adoption of digital assessments. Experienced teachers adopted digital tools more effectively than novices, while gender was not significant, consistent with findings of Redecker (2020) that professional expertise outweighs demographic factors in technology use. These outcomes reinforce TPACK theory of Mishra & Koehler (2016) and UNESCO's (2021) emphasis on the equity potential of digital platforms. The variability in adoption also reflected systemic inequalities, consistent with Uko's (2019, 2024) evidence that infrastructural disparities constrain e-assessment practices in Nigerian higher education.

Qualitative Discussion of Findings (Thematic Presentation)
The qualitative findings from the focus group interviews were organized into key themes, which supported and enriched the quantitative results.

Theme 1: Engagement and Motivation through Digital Assessment
Students consistently described digital assessments as engaging and motivating. The interactive nature of the tools transformed assessment into an enjoyable learning experience, thereby increasing participation and sustained interest.
P1: "Digital quizzes make me want to practice more."
P4: "It feels like a game, not a test."
These responses indicate that digital assessments promote active learning and intrinsic motivation. This aligns with Social and Emotional Learning (SEL) Theory, which emphasizes the role of engaging environments in fostering students' self-awareness and positive learning attitudes. The findings corroborate those of Aguilar et al. (2022), who reported that students value the autonomy and engagement provided by digital platforms.

Theme 2: Instant Feedback and Self-Monitoring
Another prominent theme was the value of immediate feedback, which enhanced students' ability to monitor and regulate their learning. Participants highlighted how digital tools enabled them to quickly identify and correct errors.
P2: "I can see my mistakes immediately and fix them."
This suggests that digital assessments function as effective formative tools, promoting metacognitive skills and self-directed learning. The finding is consistent with Alruwais et al. (2020), who emphasized that timely feedback significantly improves students' emotional and cognitive engagement.

Theme 3: Technical and Infrastructural Challenges
Despite the benefits, students reported several technical challenges that affected their assessment experience. These included unstable internet connectivity and system disruptions.
P6: "Sometimes the internet cuts off during the test."
Such challenges introduced anxiety and could negatively affect performance, thereby explaining the variation observed in resilience scores in the quantitative data. These findings highlight the critical role of infrastructure in the successful implementation of digital assessments.

Theme 4: Digital Competence of Teachers
Students also pointed out disparities in teachers' ability to effectively use digital assessment tools.

P3: “Not all teachers know how to use the tools well.”
This suggests that teacher competence is a significant moderating factor in the effectiveness of digital assessments. Where teachers demonstrate high digital proficiency, students’ learning experiences improve significantly. This reinforces the need for continuous professional development in digital pedagogy.

Theme 5: Equity and Fairness Concerns
Issues of fairness emerged as another important theme, particularly regarding unequal access to devices and internet quality.
P5: “If your device is slow, you’re at a disadvantage.”
This highlight concerns about digital equity and inclusion. From the perspective of SEL Theory, such disparities may affect students’ sense of belonging and fairness within the learning environment. The findings suggest that while digital assessments can enhance learning, they may also inadvertently widen inequalities if adequate support systems are not in place.

Integration with Quantitative Findings

The qualitative results provide deeper insight into the quantitative outcomes. While mean scores indicated improved academic achievement and non-cognitive outcomes, the relatively high standard deviation in some variables reflects differences in students’ access to digital resources, prior exposure, and teacher competence. Moderate to low standard deviation values in other areas suggest that digital assessments can create relatively uniform learning benefits, particularly when infrastructural and instructional conditions are favourable. Notably, the reduced variability in academic achievement among students exposed to digital assessments indicates that weaker students benefited more, thereby narrowing performance gaps. This supports equity-driven assessment theories and aligns with global education goals advocated by UNESCO (2021).

Overall, the implications of findings demonstrate that digital performance-based assessments serve dual functions: Cognitive tools, enhancing academic achievement. Affective tools, strengthening motivation, resilience, and SEL competencies. However, their effectiveness depends largely on teacher expertise, digital literacy, and infrastructural support rather than demographic variables. These results validate and extend prior studies, including those of Uko and colleagues (2018–2025), confirming the transformative potential of digital innovations in assessment and learner development, particularly within STEM education contexts.

Conclusion and Recommendations

The study concludes that digital assessment tools, when effectively integrated, significantly enhance both academic achievement and non-cognitive attributes in STEM education. The positive relationship between these tools and motivational as well as self-regulatory skills highlights the potential of assessment to transcend traditional measurement and act as a catalyst for learning. The findings affirm the Constructivist Theory, which posits that learning occurs through active engagement with tasks and reflection. Digital assessments create such environments, allowing learners to build knowledge through interactive problem-solving. Furthermore, the results align with the Social Emotional Learning (SEL) framework, confirming that technology-enhanced feedback can foster resilience, persistence, and self-regulation. Finally, insights from Assessment for Learning (AfL) support the conclusion that formative, digitalized approaches can empower students to become active participants in their own learning journey. Based on the findings, the following recommendations are made: For practice, professional development programs should strengthen teachers' capacity to design and administer digital assessments effectively. Institutions must prioritize ICT infrastructure, technical support, and equitable access to digital tools. For students, embedding digital literacy training into curricula will help maximize the benefits of e-assessment while minimizing the digital divide. At the policy level, governments and educational bodies should establish frameworks that standardize and sustain digital assessment practices, while addressing infrastructural disparities across institutions. Finally, future research should investigate the longitudinal impacts of digital assessments on cognitive and socio-emotional development, as well as conduct comparative analyses of adaptive AI-driven assessments and conventional digital platforms. Collectively, these findings validate and extend the works of Uko and colleagues (2018–2025), underscoring the transformative role of digital assessments in promoting reliable, equitable, and learner-centered education in STEM disciplines.

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