AN EXAMINATION OF THE INFLUENCE OF AI-BASED ASSESSMENT TOOLS FOR EFFECTIVE IMPLEMENTATION OF STEAM EDUCATION IN PRIVATE SECONDARY SCHOOLS IN RIVERS STATE

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ABSTRACT

The study examined the influence of AI-based assessment tools for effective implementation of STEAM (Science, Technology, Engineering, Arts and Mathematics) education in private secondary schools in Rivers State, Nigeria. The study adopted a descriptive survey research design. The study was conducted across private secondary schools in Rivers State, which includes diverse educational zones and both urban and rural learning environments. The population consisted of 3,280 STEAM subject teachers and 7,220 Senior Secondary School II (SS II) students offering STEAM subjects. Simple random sampling was used to select schools from the local government areas, while stratified sampling was used to select respondents within the chosen schools. A total of 192 respondents comprising 62 teachers and 130 students participated in the study. Data were collected using a structured questionnaire titled Examination of AI-Based Assessment Tools for Effective Implementation of STEAM Education (EABATEISTEAME). Validation was conducted by experts in Educational Technology and Measurement and Evaluation, while reliability testing using Cronbach's Alpha produced a coefficient of 0.86, indicating good internal consistency. Mean and standard deviation were used to answer research questions, while independent samples t-test tested hypotheses at 0.05 significance level. Conclusively, AI-based assessment tools contribute significantly to improving feedback, evaluation efficiency, and interdisciplinary learning within STEAM education in private secondary schools, Rivers State. It was recommended that educational authorities should encourage the adoption and training of teachers in the use of AI-based assessment tools to strengthen the effective implementation of STEAM education in private secondary schools.

Keywords: AI-based assessment, STEAM education, secondary schools, educational technology, Rivers State

INTRODUCTION

The twenty-first century has witnessed a significant transformation in education due to rapid technological advancement, globalization, and rising demand for innovative human capital. Education systems worldwide are gradually shifting from traditional subject-based teaching toward interdisciplinary approaches that promote creativity, collaboration, and practical problem-solving. Within this evolving context, STEAM education has emerged as a major reform strategy. STEAM integrates Science, Technology, Engineering, Arts, and Mathematics into a unified framework designed to enhance both technical competence and creative thinking. Perignat and Katz-Buonincontro (2019) noted that the incorporation of arts into STEM disciplines broadens cognitive engagement and fosters innovation, which is essential for preparing learners to address complex societal and economic challenges. As such, many countries now view STEAM education as a strategic approach to improving educational quality and strengthening competitiveness in knowledge-driven economies. The effective implementation of STEAM education depends heavily on the alignment between pedagogy and assessment. Assessment plays a critical role in shaping what students learn, how teachers deliver instruction, and how learning outcomes are evaluated. Traditional assessment practices, which rely predominantly on standardized testing and rote memorization, may not adequately capture the interdisciplinary knowledge, creativity, and collaboration emphasized in STEAM learning in the twenty-first century. Herro et al. (2017) argued that meaningful assessment in STEAM should focus on higher-order thinking, design processes, and real-world problem-solving skills rather than simple recall of facts. This has created a demand for innovative assessment systems that evaluate complex learning outcomes and provide actionable feedback to both teachers and learners.

The rapid development of Artificial Intelligence (AI) technologies has created new opportunities for enhancing educational assessment. AI in education includes machine learning algorithms, natural language processing, predictive analytics, and intelligent digital systems aimed at improving teaching and learning processes. AI-based assessment tools are increasingly recognized for their ability to evaluate student performance efficiently while providing immediate and personalized feedback. Zawacki-Richter et al. (2019) stated that AI-driven systems can automatically grade assignments, analyze patterns in student responses, and generate insights to improve instructional strategies. Unlike conventional assessment methods, AI-based tools provide adaptive learning environments that adjust to individual learner needs, supporting differentiated instruction and formative assessment. The significance of AI-based assessment tools in STEAM education is particularly noteworthy because STEAM emphasizes inquiry, experimentation, and project-based activities. Evaluating these complex learning processes requires systems capable of capturing multiple dimensions of student performance. AI-enhanced assessment tools can track progress over time, analyze digital projects, and provide real-time feedback that supports continuous learning improvement. Luckin et al. (2016) highlighted that these capabilities align closely with the principles of STEAM, where iterative problem-solving, creativity, and reflection are central to mastery. Furthermore, AI technologies can help teachers manage the workload associated with assessing interdisciplinary projects, allowing greater engagement with students' learning processes.

Despite global progress, access to advanced educational technologies remains uneven, especially in developing countries. In Nigeria, educational reforms emphasize integrating information and communication technologies (ICT) into teaching and learning; however, implementation is inconsistent. The Federal Ministry of Education (FME, 2019) reports that inadequate infrastructure, limited funding, unstable electricity supply, and insufficient teacher training hinder effective technology adoption in many secondary schools. Rivers State illustrates both opportunities and challenges: while some urban schools possess computer labs and internet access, many others struggle with limited resources and inadequate technical support. Research on Nigerian secondary schools indicates that availability of digital tools does not ensure effective pedagogical use. Aduwa-Ogiegbaen and Iyamu (2017) noted that many teachers lack technical competence and institutional support to integrate advanced technologies into assessment and instruction. Additionally, many schools rely heavily on summative examinations that promote rote learning rather than creativity and critical thinking. Such practices conflict with the interdisciplinary and innovation-focused goals of STEAM education, highlighting the need for assessment reforms that reflect its philosophy.

Teacher readiness is also critical in AI adoption. Effective use depends on digital literacy, confidence, and perceptions of technological usefulness. Zawacki-Richter et al. (2019) emphasized that integration requires structured capacity-building and institutional support. Inadequate training or perceived complexity may lead to resistance, and variations in teacher competencies and professional development opportunities in private secondary schools in Rivers State. Ethical concerns must also be addressed. Issues such as data privacy, algorithmic bias, and unequal access are central to responsible AI integration. Holmes et al. (2022) caution that AI systems trained on limited datasets may produce inequitable outcomes. In contexts with uneven digital resources, AI implementation without safeguards may exacerbate existing inequalities.

Given Nigeria's goals of strengthening science and technology education and diversifying the economy, STEAM education presents a critical pathway for cultivating interdisciplinary problem-solving and innovation skills. However, its effectiveness depends on assessment mechanisms that accurately measure these competencies. AI-based assessment tools offer adaptive feedback, monitor learning progress, and support evidence-based instructional decision-making. Therefore, investigating the influence of AI-based assessment tools on STEAM implementation in private secondary schools in Rivers State is essential for informing policy, guiding teacher training, and promoting equitable technological integration, ultimately supporting sustainable educational development.

Statement of the Problem

The increasing emphasis on STEAM education reflects a global effort to equip learners with interdisciplinary knowledge, creativity, and problem-solving skills required in technology-driven societies. The effectiveness of STEAM implementation, however, depends largely on assessment practices that align with its integrative and innovation-focused philosophy. Traditional assessment models in many secondary schools continue to prioritize summative examinations and rote memorization, which may not adequately capture the collaborative, design-oriented, and higher-order thinking competencies central to STEAM (Perignat & Katz-Buonincontro, 2019). In Rivers State, secondary schools assessment systems remain predominantly examination-driven, with limited integration of technology-enabled tools for formative, adaptive, and performance-based evaluation. This disconnects between STEAM pedagogy and conventional assessment raises concerns about whether intended learning outcomes can be fully achieved.

Artificial intelligence (AI) has significant potential to transform educational assessment through adaptive testing, automated feedback, and data-informed instructional decision-making. AI-based assessment tools can analyze learner responses in real time, provide personalized feedback, and reduce teacher workload, thereby supporting differentiated instruction (Zawacki-Richter et al., 2019). Inspite of these advantages, adoption of AI technologies in secondary education, particularly in developing contexts, remains limited and uneven. In Nigeria, infrastructural deficits, inadequate teacher training, and inconsistent policy implementation continue to constrain meaningful technology integration (Federal Ministry of Education [FME], 2019). Rivers State mirrors these challenges, where digital tools exist in some schools but are often underutilized for instructional and assessment purposes.

Holmes et al. (2022) emphasized that responding to AI integration requires contextual sensitivity, professional capacity-building, and empirical validation of outcomes. Without localized research, assumptions about AI-driven assessment may overlook digital literacy gaps, resource disparities, and ethical concerns related to data use. Currently, limited empirical evidence exists on how AI-based assessment tools influence STEAM implementation in private secondary schools, Rivers State. This research gap highlights the need for systematic investigation to inform evidence-based practice, guide policy formulation, and enhance the quality and relevance of secondary education in the region.

Aim and Objectives of the Study

The aim of this paper is to examine the influence of AI-based assessment tools for effective implementation of STEAM education in private secondary schools, Rivers State. The specific objectives of the study are to examine the:

1. Influence of Labster as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.

2. Influence of Chatgpt as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.

3. Influence of PhET Interactive Simulations as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.

Research Questions

The following research questions will guide the study:

1. Does Labster, as AI-based assessment tool influence effective implementation of STEAM education in private secondary schools, Rivers State?

2. Does Chatgpt, as AI-based assessment tool influence effective implementation of STEAM education in private secondary schools, Rivers State?

3. Does PhET Interactive Simulations, as AI-based assessment tool influence effective implementation of STEAM education in private secondary schools, Rivers State?

Hypotheses

The following hypotheses will be tested at 0.05 level of significance:

1. There is no significant difference on the Influence of Labster as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.

2. There is no significant difference on the Influence of Chatgpt as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.

3. There is no significant difference on the Influence of PhET Interactive Simulations as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.

Theoretical Review

This study adopted two (2) theories: Technology Acceptance Model (TAM) and Diffusion of Innovation Theory (DIT).

The Technology Acceptance Model (TAM), developed by Davis (1989), is a theoretical framework designed to explain and predict how users accept and adopt technology. Davis identified two key factors influencing behavioural intention: perceived usefulness and perceived ease of use. Perceived usefulness refers to the extent to which an individual believes a system enhances performance, while perceived ease of use reflects the degree to which using the system is effort-free. These beliefs shape behavioural intention, which in turn affects actual technology usage. Over time, TAM has been widely applied in educational technology research to examine teachers' and learners' adoption of innovations, including learning management systems, mobile learning, and intelligent educational tools (Venkatesh & Davis, 2000). TAM was later extended into TAM2 by Venkatesh and Davis (2000), integrating social influence and cognitive instrumental processes that affect perceived usefulness. This extension improved the model's explanatory power, making it one of the most widely used frameworks for understanding technology adoption in educational contexts (King & He, 2006; Teo, 2011). TAM's simplicity and predictive capability allow researchers to capture both individual attitudes and behavioural intentions, offering a structured approach to analyzing technology integration.

Venkatesh and Bala (2008) emphasized that users' beliefs about technology significantly shape how innovations are applied, a principle relevant to complex tools like AI-based assessment systems. In Rivers State private schools, TAM provides a useful lens to examine teachers' adoption of AI-based assessment tools for STEAM education. Perceived usefulness may involve beliefs that AI can enhance feedback quality, reduce workload, and align assessments with STEAM competencies, while perceived ease of use influences teachers' willingness to experiment with AI tools, particularly where digital literacy varies. External factors, such as infrastructure, professional development, and administrative support, indirectly affect technology acceptance by shaping users' beliefs (Venkatesh & Davis, 2000). Applying TAM in this context can illuminate attitudinal and contextual factors that enable or hinder AI adoption, providing insights into effective implementation strategies for supporting STEAM education objectives in Rivers State.

Diffusion of Innovation Theory (DIT) – (Rogers, 1962)

Everett M. Rogers introduced the Diffusion of Innovation Theory (DIT) in 1962 to explain how, why, and at what rate new ideas and technologies spread through social systems. Rogers defined diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 2003, p. 5). Adoption occurs through stages - knowledge, persuasion, decision, implementation, and confirmation and is influenced by innovation attributes, communication channels, time, and the social system. Innovators, early adopters, early majority, late majority, and laggards illustrate the adoption curve. Innovations with relative advantage, compatibility, simplicity, trialability, and observable results are more likely to be adopted quickly (Rogers, 2003). DIT has been applied in education, agriculture, and public health to understand technological uptake and guide effective implementation strategies. Rogers (2003) emphasized that the social system shapes diffusion, highlighting the importance of norms, teacher beliefs, and organizational structures in schools. Opinion leadership and social learning explain why some teachers or institutions adopt technology earlier than others. Greenhalgh et al. (2004) further noted that organizational readiness, leadership support, and feedback mechanisms influence innovation adoption, showing that diffusion relies on embedding technology within a supportive system rather than mere introduction.

Valente (1996) illustrated that peer influence and interpersonal networks are critical for spreading new practices, including educational technologies. In schools, factors such as culture, access to training, and visible instructional benefits affect teachers' willingness to integrate ICT. For this study, DIT provides a framework for understanding how AI-based assessment tools spread in private secondary schools, Rivers State. AI assessments diverge from traditional methods, and uptake depends on perceived advantage, compatibility with STEAM pedagogy, and ease of experimentation. Infrastructure, teacher readiness, and institutional support further shape diffusion. DIT thus enables analysis of not only whether AI tools are adopted but how and why adoption occurs, guiding tailored policy and practice recommendations.

Overview of STEAM Education

STEAM education is a transformative approach that integrates Science, Technology, Engineering, the Arts, and Mathematics to prepare learners for complex problem-solving and innovation in the twenty-first century. Expanding on STEM, STEAM incorporates the arts to foster creativity, design thinking, and aesthetic sensibilities alongside analytical skills (Perignat & Katz-Buonincontro, 2019). This approach reflects a recognition that creativity is central to scientific and technological advancement. Educators and policymakers advocate for STEAM because it mirrors real-world challenges, where disciplinary boundaries are porous and solutions require both technical rigor and imaginative insight. Integrating the arts shifts instruction from rote memorization toward project-based, inquiry-oriented learning. Kolb's experiential learning theory posits that meaningful learning occurs through cycles of experience, reflection, conceptualization, and experimentation (Kolb, 2015). STEAM classrooms emphasize hands-on projects requiring collaboration, iterative design, and reflection, helping students connect abstract mathematics and scientific principles to tangible creations. This cross-disciplinary focus enhances motivation, retention, and the ability to recognize patterns across subjects. STEAM education also aligns with workforce demands in a digital, innovation-driven economy. The World Economic Forum (2020) emphasized creativity, critical thinking, and complex problem-solving as essential skills. STEAM equips students with technical literacy and creative agency, which traditional assessments often fail to measure. Educators are thus encouraged to adopt assessment practices that capture design thinking, collaboration, and iterative problem solving, reflecting real-world competencies. Implementation challenges include the need for professional development, resources, and supportive leadership. Darling-Hammond et al. (2020) argued that successful innovation depends on teacher collaboration, curriculum coherence, and formative assessment aligned with new learning goals. In resource-constrained contexts or where educators lack preparation, STEAM initiatives may struggle. Nevertheless, evidence shows that thoughtful implementation enhances engagement, achievement, and transferable skills, marking a paradigm shift toward learner-centered, problem-solving education.

Artificial Intelligence in Education (AIEd)

AIEd leverages computational technologies to enhance teaching, learning, and assessment. It includes machine learning, natural language processing, and data analytics to personalize instruction, provide real-time feedback, and support adaptive learning pathways (Holmes et al., 2019). Intelligent tutoring systems, automated assessments, and personalized learning tools adjust to individual student performance, addressing limitations of one-size-fits-all instruction. Woolf (2020) noted that AI enables teachers to analyze data, identify misconceptions, and offer targeted interventions, especially in large classrooms. Ethical considerations such as transparency, privacy, and equitable access are essential for responsible implementation (Popenici & Kerr, 2017).

AI in Educational Assessment

AI transforms assessment by moving from static testing to dynamic, data-informed evaluation. Systems analyze student interactions, provide immediate feedback, and adapt tasks to learner profiles (Baker & Inventado, 2014). Intelligent tutoring and automated essay scoring illustrate how AI enhances efficiency and supports both formative and summative assessment. AI captures learning behaviors often overlooked by traditional methods, such as problem-solving pathways and collaborative interactions, providing a holistic view of achievement (Holmes, Bialik, & Fadel, 2019). Ethical implementation is critical to ensure fairness, transparency, and alignment with pedagogical goals, preventing bias and misuse of learner data (Williamson & Eynon, 2020). When responsibly integrated, AI offers significant potential to modernize assessment and support effective STEAM education.

AI-Based Assessment Tools

AI based assessment tools represent a significant shift in how educators measure and interpret student learning, moving beyond conventional paper and pencil tests to systems that leverage intelligent algorithms, data analytics, and adaptive technologies (Luckin et al., 2016). These tools are designed to analyze student responses in real time, provide instantaneous feedback, and adapt subsequent tasks to match individual learning profiles. Adaptive testing platforms, for example, adjust question difficulty based on a student's performance, enabling more precise measurement of competencies while maintaining engagement (Van der Linden & Glas, 2010). Such technologies hold promise for enhancing both formative and summative assessment processes, allowing teachers to monitor progress continuously and tailor instruction responsively. Holmes, Bialik, and Fadel (2019) noted that AI based assessment tools can capture dimensions of learning that traditional assessments often overlook, including problem solving strategies, collaborative interactions in digital environments, and the application of higher order skills. Intelligent tutoring systems exemplify this integration by not only scoring responses but also diagnosing misconceptions and recommending personalized learning pathways. These strengths are particularly relevant in interdisciplinary learning contexts such as STEAM education, where competencies are multifaceted and not easily reducible to single score outcomes.

Despite their potential, ethical and practical challenges accompany the implementation of AI based assessment tools. Williamson and Eynon (2020) highlighted concerns about data privacy, algorithmic transparency, and equitable access, warning that without clear governance frameworks, AI systems can inadvertently reinforce bias or reduce complex learner profiles to oversimplified metrics. Teacher readiness and professional development are also critical factors; educators must understand how to interpret and act on data generated by these systems to support meaningful learning improvements. Emerging research shows that when AI based assessment tools are thoughtfully integrated into instructional practice, they can contribute to more nuanced understanding of student learning trajectories and support differentiated instruction. Their capacity to deliver timely, targeted feedback aligns with contemporary pedagogical ideals that prioritize learner agency and adaptive teaching, making them compelling components of modern educational ecosystems.

Influence of Labster as AI-based assessment tools for effective implementation of STEAM education

The integration of AI-supported virtual laboratories such as Labster into STEAM education represents a significant shift in how scientific knowledge and interdisciplinary competencies have developed. Digital simulation platforms allow learners to conduct experiments in interactive environments without the financial, safety, or logistical constraints of physical labs. Bonde et al.

(2014) reported that gamified simulations significantly improved learning outcomes in biotechnology courses compared to traditional instruction, demonstrating that platforms like Labster enhance conceptual understanding while maintaining high student engagement. STEAM education emphasizes inquiry, creativity, collaboration, and applied problem solving, which align closely with AI-driven simulation design. Makransky, Thisgaard, and Gadegaard (2016) found that virtual lab simulations increased students' intrinsic motivation and learning outcomes relative to conventional multimedia instruction. Labster situates learners in narrative-driven scientific challenges, requiring application of theoretical knowledge to realistic scenarios. Such immersive experiences promote cognitive engagement and deeper processing, supporting STEAM's interdisciplinary goals.

Assessment in STEAM requires measuring not only factual recall but also procedural knowledge and critical thinking. AI-based virtual labs provide immediate feedback, adaptive guidance, and performance analytics for instructors to monitor student progress in real time. Makransky et al. (2019) showed that combining virtual reality simulations with lab instruction enhanced knowledge acquisition and self-efficacy, which is critical for persistence in challenging STEM tasks. AI-supported feedback loops reinforce formative assessment principles, enabling learners to correct misconceptions instantly. Accessibility and scalability further strengthen Labster's influence. Brinson (2015) concluded that online labs can produce learning outcomes comparable to traditional labs, which is crucial for institutions with limited infrastructure or large student populations. AI-based laboratories democratize access to advanced experiments, promoting equity and inclusion in STEAM education.

Cognitive load considerations also inform effectiveness. Makransky, Terkildsen, and Mayer (2019) noted that structured guidance, embedded quizzes, and scaffolded problem-solving help regulate attention and reduce extraneous load. Finally, effective implementation requires pedagogical alignment rather than technological substitution. De Jong, Linn, and Zacharia (2013) emphasized that simulations are most effective when combined with hands-on experiences and guided instruction, complementing rather than replacing physical experimentation. Labster's impact lies in its integration of motivation, adaptive assessment, and scalable access. Evidence from Bonde et al. (2014), Makransky et al. (2016, 2019), Brinson (2015), and de Jong et al. (2013) supported the conclusion that AI-based virtual laboratories can significantly enhance STEAM education when embedded within coherent instructional strategies, promoting engagement, equity, and pedagogical effectiveness.

Influence of Chatgpt as AI-based assessment tools for effective implementation of STEAM education

The rapid advancement of AI tools such as ChatGPT has generated scholarly interest in their role in STEAM (Science, Technology, Engineering, Arts, and Mathematics) education. Reviews indicate that ChatGPT can personalize learning, automate assessment, and reduce educator workload, while raising ethical and equity concerns requiring careful governance (Munaye et al., 2025). These findings suggest that generative AI's impact is significant but not automatic or uniformly positive. Empirical evidence highlights ChatGPT's potential to enhance learning when embedded within pedagogical frameworks. A meta-analysis of over fifty studies found its use positively influenced learning performance, improved students' perceptions of learning, and enhanced higher-order thinking skills (Wang & Fan, 2025). When students engage with ChatGPT as an interactive partner rather than a shortcut, it supports deeper conceptual understanding, aligning with STEAM's emphasis on inquiry, analysis, and problem-solving.

Research also demonstrates ChatGPT's utility in instructional planning. Luo and Tahir (2025) reported that AI-assisted lesson plans in STEAM arts education scored higher in quality, efficiency, and interdisciplinary coherence than traditional plans, suggesting AI can help teachers manage complex curricula while fostering collaboration and critical thinking. Systematic reviews highlight additional benefits, including increased engagement, just-in-time explanations, and personalized learning pathways (Ali et al., 2024). However, concerns remain about response quality, bias, and authenticity of AI-generated work, emphasizing the need for ethical frameworks and careful instructional design. Assessment is a critical area for consideration. Gao (2024) noted that traditional assessments may fail to distinguish student understanding from AI-generated responses, underscoring the need for tasks that evaluate reasoning, creativity, and interdisciplinary problem-solving. Responsible adoption requires balancing AI support with student autonomy, establishing policies, and training educators to integrate AI effectively (Munaye et al., 2025).

In STEAM classrooms, ChatGPT can enhance engagement, scaffold complex problems, and provide formative feedback, supporting constructivist pedagogies. Evidence from meta-analyses, experimental studies, and reviews (Wang & Fan, 2025; Luo & Tahir, 2025; Ali et al., 2024; Munaye et al., 2025) indicates that when used intentionally, ChatGPT can improve learning outcomes, support higher-order thinking, and enrich instructional design while requiring ethical oversight and AI literacy to maximize its educational benefits.

Influence of PhET Interactive Simulations as AI-based assessment tools for effective implementation of STEAM education

PhET Interactive Simulations have emerged as a significant digital tool in STEAM education, particularly for enhancing visualization, experimentation, and inquiry-based learning. These simulations allow students to manipulate variables, test hypotheses, and observe dynamic outcomes in virtual scientific environments. Empirical evidence demonstrates their instructional value. Banda and Nzabahimana (2023) reported that Malawian secondary students using PhET in physics achieved higher academic performance than peers in traditional settings, alongside gains in motivation, self-efficacy, and attitudes toward science, indicating that interactive simulations support both conceptual mastery and positive learning dispositions. Cognitive development in STEAM requires students to move beyond memorization toward application, analysis, and creative problem-solving. Rayan, Daher, Diab, and Issa (2023) found that elementary students engaging with PhET progressed through multiple cognitive levels, including understanding, applying, and generating solutions collaboratively. Simulations encouraged discussion, hypothesis testing, and reflection, aligning with constructivist principles and supporting inquiry-oriented STEAM goals. Such platforms also function as dynamic assessment environments, where learning evidence emerges through interaction rather than static tests.

Beyond individual achievement, PhET simulations facilitate broader instructional transformation. Diab, Daher, Rayan, Issa, and Rayan (2024) observed measurable improvements in students' conceptual understanding and learning outcomes, noting that variable manipulation made misconceptions visible and correctable, enabling targeted feedback. Motivation and affective outcomes are also enhanced; students demonstrate increased intrinsic motivation and confidence, reduced anxiety in experimentation, and greater collaborative engagement (Banda & Nzabahimana, 2023; Rayan et al., 2023). Effective implementation requires pedagogical alignment. Diab et al. (2024) emphasized structured guidance, reflective prompts, and purposeful lesson design to ensure conceptual clarity rather than superficial interaction. When integrated with sound instructional strategies, PhET simulations merge visualization, inquiry, collaboration, and formative assessment into a single platform. Evidence consistently shows that such integration improves academic achievement, conceptual understanding, and motivation, positioning PhET as a valuable tool for effective STEAM education.

Challenges of AI Integration in Nigerian Schools

Integrating Artificial Intelligence (AI) into Nigerian schools faces significant barriers beyond technological interest. Infrastructure deficits remain a foundational challenge, as many secondary schools lack reliable electricity, stable internet, and access to digital devices. These limitations severely restrict the use of cloud-based AI platforms and adaptive learning systems. Research in Rivers State highlights that erratic power supply and poor connectivity hinder consistent digital tool usage in classrooms (Nwobodo & Udoka, 2025). Nationally, broadband access and technological readiness lag behind global averages, particularly in rural areas (AI in education review, 2025). Teachers' digital literacy and preparedness further impede AI adoption. Studies show that while many educators recognize AI's potential, classroom implementation remains low due to insufficient training, limited professional support, and minimal institutional encouragement (Teachers' Perceptions of AI Integration, 2025). Without robust continuing professional development, AI innovations risk underutilization, reducing their transformative impact (Assessment of AI Awareness in Osun State, 2025).

Financial constraints and policy gaps also challenge AI integration. Procuring hardware, software licenses, and technical support is costly, and many public schools cannot meet these demands. Moreover, comprehensive policies addressing AI governance, ethical use, data privacy, and equitable access are largely absent, leaving schools without clear guidance (AI trends in Nigeria education, 2025). Socioeconomic disparities exacerbate these issues, as wealthier urban schools access digital tools and training more readily than underfunded rural counterparts, reinforcing a digital divide (AI in education review, 2025). Addressing these challenges through targeted infrastructure investment, teacher development, policy frameworks, and equitable resource allocation is essential for meaningful and sustainable AI integration in Nigerian schools.

Methodology

This study adopted a descriptive survey research design to examine the influence of AI-based assessment tools for effective implementation of STEAM education in private secondary schools in Rivers State. The design was considered appropriate because it allows for systematic collection of data from a defined population in order to describe existing conditions and determine relationships among variables without manipulation. The study was conducted in Rivers State, Nigeria, which comprises multiple educational zones and a mixture of urban and rural secondary schools. The population consisted of private senior secondary schools in the state offering STEAM-related subjects (Science, Mathematics, Technical Drawing, Computer Science, Fine Arts, and related disciplines). The target respondents included STEAM subject teachers and senior secondary school students (SS II), as this level represents a critical stage where interdisciplinary learning and external examination preparation intersect. Records from the Rivers State Ministry of Education estimated the population of 3,280 STEAM teachers and 7,220 SS II students across the state's private secondary schools. A multi-stage sampling procedure was employed. First, simple random sampling was applied to select schools from each local government areas, and then Stratified sampling was used to select STEAM teachers and SS II students within the chosen schools. The final sample size consisted of 192 respondents (62 teachers and 130 students). Data were collected using structured instrument (questionnaire) developed by the researcher. The questionnaire was titled: *'Examination of AI-Based Assessment Tools for Effective Implementation of STEAM Education (EABATEISTEAME)'* The instrument consisted of 2 sections: demographic information of respondents and the items (statements). Responses were measured on a four-point Likert scale ranging from Strongly Agree (4) to Strongly Disagree (1). The instrument was subjected to face and content validation by two experts in Educational Technology and

Measurement and Evaluation in Rivers State University. Their suggestions regarding clarity, relevance, and alignment with research objectives were incorporated before final administration of the instruments. A pilot test was conducted in two secondary schools outside the sampled population. Reliability of the instrument was established using Cronbach's Alpha coefficient and yielded a reliability index of 0.86 indicating acceptable internal consistency. Descriptive statistics such as mean and standard deviation were used to answer research questions while independent samples t-test was used to test the hypotheses at 0.05 level of significance. This methodological approach provided a systematic and empirical basis for examining the role of AI-based assessment tools in enhancing the effective implementation of STEAM education in private secondary schools, Rivers State.

Findings and Discussions

Research Question 1.

Does Labster, as AI-based assessment tool influence effective implementation of STEAM education in private secondary schools, Rivers State?

Table 1 - Mean and standard deviation showing the Influence of Labster as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.

S/N	STATEMENTS	$\bar{x}$	SD	Remark
1	Labster simulations improve students' understanding of complex STEAM concepts through interactive and visual learning experiences.	3.28	1.02	**Agree**
2	The AI-based feedback provided by Labster helps students identify and correct misconceptions during learning activities.	3.36	0.67	**Agree**
3	Labster enhances students' problem-solving and critical thinking skills required for effective STEAM learning.	3.11	0.78	**Agree**
4	The assessment features in Labster allow teachers to monitor students' progress and learning outcomes effectively.	3.32	0.91	**Agree**
5	Using Labster does not increase students' engagement and motivation in STEAM subjects.	2.30	1.11	**Disagree**
	Criterion mean	**3.07**	**0.89**	**Agree**

The data in Table 1 show a criterion mean of 3.07, which is above the decision benchmark of 2.50, indicating respondents' agreeing to the fact that Labster, as an AI-based assessment tool, supports the effective implementation of STEAM education in private secondary schools, Rivers State. Items 1, 2, 3 and 4 recorded mean scores of 3.28, 3.36, 3.11 and 3.32 respectively, indicating that Labster simulations does improve students' understanding of complex STEAM concepts through interactive and visual learning experiences; it helps in providing feedback to students by identifying and correcting misconceptions during learning; it enhances students' problem-solving and critical thinking skills; it allows teachers to monitor students' progress and learning outcomes effectively. In addition, respondents in item 5 also disagreed ($\bar{x}$ = 2.30 which is less than the criterion mean of 2.50) that Labster actually does not increase students' engagement and motivation in STEAM subjects, an indication that Labster increases students 'engagement and motivation.

This finding resonates with the assertion of Bonde et al. (2014) who reported that gamified laboratory simulations significantly improved learning outcomes in biotechnology courses when compared with traditional mode of instruction alone, highlighting the pedagogical value of immersive digital tools. In the same vein, Makransky, Thisgaard, and Gadegaard (2016) found that virtual laboratory simulations enhanced students' intrinsic motivation and learning outcomes when compared with more conventional multimedia instruction.

Research Question 2

Does ChatGPT, as AI-based assessment tool influence effective implementation of STEAM education in private secondary schools, Rivers State?

Table 2 - Mean and standard deviation showing the influence of Chatgpt as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.

S/N	STATEMENTS	$\bar{x}$	SD	Remark
6	ChatGPT enhances students' understanding of complex STEAM concepts by providing immediate explanations and examples.	3.61	0.56	**Agreed**
7	The AI-based feedback from ChatGPT helps students identify gaps in their knowledge and improve problem-solving skills.	3.43	0.71	**Agree**
8	ChatGPT supports teachers in designing assessments and monitoring students' learning progress effectively.	3.34	0.82	**Agree**

9	Interaction with ChatGPT decreases students' engagement, curiosity, and motivation in STEAM subjects.	1.98	0.77	**Disagree**
10	Integrating ChatGPT into classroom instruction improves the effectiveness of STEAM education compared to conventional teaching and assessment methods.	3.66	0.63	**Agree**
	Criterion mean	**3.20**	**0.69**	**Agree**

From the data in Table 2 above, it shows a criterion mean of 3.20, which is above the benchmark of 2.50, indicating respondents' concurring to the fact that ChatGPT as an AI-based assessment tool supports the effective implementation of STEAM education in private secondary schools, Rivers State. Items 6, 7, 8, and 10 recorded mean scores of 3.61, 3.43, 3.34, and 3.66 respectively, showing agreement that ChatGPT enhances conceptual understanding of complex STEAM concepts by providing immediate explanations with examples; it provides useful feedback by helping students identifying gaps in their knowledge; it supports teachers in designing assessments and monitoring students progress in learning, and integrating it into classroom instructional mode by improving STEAM education when compared to conventional teaching and assessments methods. Moreover, respondents in Item 9 ($\bar{x}$ = 1.98), disagreed that ChatGPT does reduce students' engagement, curiosity and motivation in STEAM subjects. Implying that ChatGPT increases students' engagement, curiosity and motivation.

The statements made by Luo and Tahir (2025) after their study of specific ways ChatGPT can support educators in planning and instructional design, particularly within STEAM fields; support the finding of this study. They found that ChatGPT-assisted lesson plans significantly outscored traditional plans in quality, efficiency, and interdisciplinary coherence. Teachers using ChatGPT generated materials that aligned more consistently with creative and integrative learning goals, indicating that AI can help educators manage the complexity of STEAM curricula while fostering 21st-century skills such as collaboration and critical thinking.

Research Question 3

Does PhET Interactive Simulations, as AI-based assessment tool influence effective implementation of STEAM education in private secondary schools, Rivers State?

Table 3 - Mean and standard deviation showing the influence of PhET Interactive Simulations as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.

S/N	STATEMENTS	$\bar{x}$	SD	Remark
11	PhET Interactive Simulations enhance students' understanding of complex STEAM concepts through interactive and visual learning experiences.	3.31	0.91	**Agree**
12	The AI-based feedback embedded in PhET simulations does not help students identify and correct misconceptions during science experiments.	2.22	1.04	**Disagree**
13	PhET simulations allow teachers to assess students' learning progress effectively and in real time.	3.45	0.68	**Agree**
14	Using PhET simulations improves students' problem-solving and critical thinking skills in STEAM subjects.	3.28	0.86	**Agree**
15	PhET simulations support interdisciplinary learning by connecting concepts across science, technology, engineering, arts, and mathematics.	3.16	1.01	**Agree**
	Criterion mean	**3.08**	**0.9**	**Agree**

The data in Table 3 show a criterion mean of 3.08, which is above the benchmark of 2.50, indicating respondents' agreement that PhET Interactive Simulations support the effective implementation of STEAM education in private secondary schools, Rivers State. Items 11, 13, 14, and 15 recorded mean scores of 3.31, 3.45, 3.28, and 3.16, showing agreement that PhET improves students' understanding of complex STEAM concepts through interactive and visual learning experiences; it allow teachers to assess students' learning progress effectively in real-time assessment; it improves students' problem-solving and critical thinking skills in STEAM subjects; and promotes interdisciplinary learning by connecting concepts across science, technology, engineering, arts, and mathematics. Furthermore, respondents disagreed with Item 12 ($\bar{x}$ = 2.22) that PhET simulations actually does not help students identify and correct misconceptions during science experiments. This shows PhET interactive simulations aids student in identifying and correcting misconceptions during science experiments.

The finding of this study is in consonance with the assertions of Banda and Nzabahimana (2023) who reported that Malawian secondary school students who engaged with PhET simulations in physics achieved significantly higher academic performance compared to those taught through conventional approaches. Their study also revealed notable gains in students' motivation, self-efficacy, and attitudes toward physics, suggesting that interactive simulations not only strengthen conceptual mastery but also foster positive learning dispositions essential for sustained engagement in STEAM disciplines.

Hypotheses Testing

1. **There is no significant difference on the Influence of Labster as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.**

Table 4 – Independent T-test summary showing significant influence of Labster as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.

Category	N	Mean	SD	df	t-cal	p-value	Decision
Teachers	**62**	3.26	0.87	190	4.84	0.032	**Rejected**
Students	**130**	3.41	0.74				**($p<0.05$)**

Table 4 shows the independent t-test results on the influence of Labster as an AI-based assessment tool for the effective implementation of STEAM education in private secondary schools, Rivers State. Teachers (M = 3.26, SD = 0.87, N = 62) and students (M = 3.41, SD = 0.74, N = 130) recorded relatively high mean scores. The calculated t-value of 4.84 with a p-value of 0.032 indicates a statistically significant difference, leading to the rejection of the null hypothesis. This invariably means that, there is significant influence of Labster as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.

2. **There is no significant difference on the Influence of Chatgpt as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.**

Table 5 – Independent T-test summary showing significant influence of Chatgpt as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.

Category	N	Mean	SD	df	t-cal	p-value	Decision
Teachers	62	3.11	1.02	190	8.22	0.024	Rejected
Students	130	3.30	0.87				($p<0.05$)

Table 5 presents the independent t-test results on the influence of ChatGPT as an AI-based assessment tool on the effective implementation of STEAM education in private secondary schools, Rivers State. Teachers (N = 62) recorded a mean score of 3.11 with a standard deviation of 1.02, while students (N = 130) had a higher mean of 3.30 and SD of 0.87. The calculated t-value of 8.22 at df = 190 with a p-value of 0.024 indicates a statistically significant difference, leading to rejection of the null hypothesis. What this means is that, there is significant influence of Chatgpt as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.

3. There is no significant Influence of PhET Interactive Simulations as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.

Table 6 – Independent T-test summary showing significant influence of PhET Interactive Simulations as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.

Category	N	Mean	SD	df	t-cal	p-value	Decision
Teachers	62	3.19	1.12	190	3.44	0.014	Rejected
Students	130	3.14	0.97				($p>0.05$)

Table 6 shows the independent t-test results on the influence of PhET Interactive Simulations as an AI-based assessment tool on the effective implementation of STEAM education in private secondary schools, Rivers State. Teachers (N = 62) had a mean score of 3.19 with a standard deviation of 1.12, while students (N = 130) recorded a mean of 3.14 and SD of 0.97. The calculated t-value of 3.44 at df = 190 and p-value of 0.014 indicates a statistically significant difference; thus, the null hypothesis is rejected. This strongly indicates that, there is significant influence of PhET Interactive Simulations as AI-based assessment tool for effective implementation of STEAM education in private secondary schools, Rivers State.

CONCLUSION

The study of AI-based assessment tools in private secondary schools, Rivers State reveals the transformative potential of Labster, ChatGPT, and PhET Interactive Simulations in STEAM education. Labster's immersive virtual laboratories provide students with interactive, gamified experiences that strengthen conceptual understanding, enhance problem-solving skills, and increase engagement in complex science and engineering topics. ChatGPT supports both learners and educators by delivering immediate, personalized feedback, fostering critical thinking, and assisting in the design and evaluation of assessments, thereby streamlining instructional processes and reinforcing higher-order learning. PhET Interactive Simulations complement these approaches by offering dynamic, visual representations of abstract scientific phenomena, enabling students to experiment safely, visualize outcomes, and connect interdisciplinary concepts across STEAM disciplines. Collectively, these tools create an environment where students actively engage in inquiry-based learning, receive real-time formative assessment, and develop both cognitive and motivational competencies necessary for success in modern STEAM curricula. The findings suggest that thoughtful integration of AI-based assessment tools not only enhances student learning outcomes but also supports teachers in delivering more effective, interactive, and adaptive instruction. Embracing these technologies in secondary education has the potential to bridge gaps in resource availability, promote equity in learning experiences, and prepare students for future scientific and technological challenges.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations are put forward:

1. Private school administrators in Rivers State should provide adequate infrastructure, including reliable internet access and compatible devices, to ensure seamless use of Labster and ChatGPT, while supporting offline or low-bandwidth options for PhET simulations where necessary.

2. Curriculum designers should align AI-based assessment tools with learning objectives, ensuring that Labster, ChatGPT, and PhET simulations complement traditional laboratory work and classroom instruction, rather than replacing essential hands-on activities.

3. Teachers should use ChatGPT to facilitate formative assessments and personalized feedback, helping students develop critical thinking, problem-solving skills, and self-directed learning habits within STEAM subjects.

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