# AFRICAN JOURNAL OF EDUCATIONAL FOUNDATIONS

***University of Uyo, January/ March, 2026 online:2672-5660, print: 2672-5649***


## Advancement and Achievement of Artificial Intelligence Technologies in STEM Education Assessment Practices


**Duru, Chukwudi Magnus (PhD), Itainyang, Anthonia Innocent & Inyang, Ita Innocent (PhD)**

Department of Science Education, Akwa Ibom State Univsersity,
Akwa Ibom State, Nigeria

[123]Email: [1]duruchukwudi06@gmail.com, [2]anthoniaitainyang@gmail.com & [3]inyangii3@gmail.com



***Abstract***

*The study investigated determined the advancement of artificial intelligence technologies in STEM education assessment practices in Akwa Ibom State, Nigeria. To achieve the purpose of the study, two research questions were raised and answered in the course of the study. A descriptive study design was adopted. This study was carried out in the south-south, Nigeria. The population for the study comprises 1249 Science Secondary School teachers in eleven public coeducational schools in Nigeria. Two hundred and nine (314) participants were estimated using Taro Yamane (1967) formula. Simple random sampling (tossing the dice) was used to draw the sample. AI advanced technologies in STEM education assessment practices questionnaire (AIATSEAPQ) instrument was developed by the researcher and used for the study. The instrument comprised 15 items with the response options on a 4-point rating scale for cluster one to be strongly agreed (SA), agree (A), disagree(D) and strongly disagree (SD) and cluster two to be Very High Extent(VHE), High Extent (HE), Low Extent (LE), Very Low Extent(VLE), with numeric values of 4, 3, 2 and 1 respectively. The instrument was face validated by 3 experts. The instrument was trial tested on 30 teachers and the reliability coefficients of 0.70 and 0.74 were obtained for clusters 1 and 2 respectively using the Cronbach Alpha method. The face-to-face method was employed in the collection of data to ensure a (100%) return. Data was analyzed using mean and standard deviation. Findings of the results obtained from this study, showed that the advancements of artificial intelligence technologies are to a Low extent been applied in STEM assessment practices. Thus, there is a limited integration of AI advancements in evaluating and measuring student performance in science, technology, engineering, and mathematics fields. Based on the findings of the result, recommendation made was the ministry and relevant education stakeholders should promote awareness and training on AI-STEM Assessment Technologies by developing workshops, training programs, or professional development sessions on enhancing teachers' understanding of advancements in AI-STEM assessment technologies.*



**Keyword:** Advancement, Artificial, Intelligence, Technologies, Assessment


### Introduction

In recent years, advancements in artificial intelligence (AI) technologies have sparked significant interest and exploration in various fields, including education. Artificial intelligence

(AI) technology has been increasingly integrated into the field of education, transforming the way students learn and teachers instruct. The use of AI in education has been seen as means to provide personalized learning experiences, offer more effective feedback, and enhance student outcomes. One of the earliest instances of AI in education can be traced back to the development of intelligent tutoring systems. These systems utilize AI algorithms to provide personalized guidance and feedback to students as they navigate through assignments and problems. Research has shown that intelligent tutoring systems can improve student learning outcomes and engagement (Richardson & Clesham, 2021). In addition, AI has been applied in the creation of adaptive learning technologies, which customize educational content based on individual students needs and learning styles. These systems dynamically adjust the pace, complexity, and content of lessons, assisting students in learning more effectively and efficiently (Wise, 2019; Koedinger, Corbett & Perfetti, 2015).

Moreover, AI technologies has been instrumental in automating various administrative tasks within education, such as grading assessments, scheduling classes, and managing student data. This automation helps educators allocate more time to teaching and mentoring students while streaming educational process (Darabi, 2020). The future implications of AI in education remain promising, with further advancements anticipated in Ai algorithms, machine learning, and natural language processing. These developments are projected to enhance the capabilities of AI systems in education, leading to even more personalized and adaptive learning experiences for students. As AI technology continues to progress, it is poised to become a pivotal component in the future of education (Duolingo, 2021).

Many Scholars have viewed the concept of Artificial Intelligence (AI) differently. According to Dwivedi, Hughes and Ismagilova (2021), AI can broadly be thought of as computerized systems that work and react in ways commonly thought to require intelligence, such as the ability to learn, solve problems, and achieve goals under uncertain and varying conditions. Pearl (2018) defined Artificial Intelligence as the science of making machines to do things that would require intelligence if done by humans. Based on these views, Artificial Intelligence (AI) can therefore be defined as the development of intelligent machines that can perform tasks that typically require human intelligence. These intelligent machines play significant roles in different fields, especially in the field of education. However, it is worthy of note that before the advent of artificial intelligence (AI) technologies, traditional teaching, learning and assessment relied heavily on in-person instruction and printed materials. Teachers were the primary source of knowledge dissemination, delivering lectures and content through textbooks. As such, students' access to information was limited to what the teachers taught in the classroom, what was available in physical libraries and therefore making research and reference time-consuming.

Moreso, Assessment was typically paper-based, for both standardized tests and exams. Personalized learning was challenging due to large class sizes, making it difficult to cater for

individual needs. Feedback was also often delayed and as such hindering students' growth. The lack of interactive tools and multimedia resources also constrained student's engagement and interactivity. In essence, traditional assessment was constrained by its physical limitations, resulting in less adaptable and dynamic learning experiences. Artificial Intelligence on the other hand can augment human capabilities, enabling scientists, engineers, and mathematicians to solve complex problems more effectively and drive innovation (Brynjolfsson & McAfee, 2017). Due to this importance, there is a need to therefore become more knowledgeable about AI technologies and more proactive in considering public policies around their use and application across educational fields.

Development of computer science and computational technologies in schools, automatic, adaptive and efficient AI technologies has been widely applied in various academic fields. Artificial Intelligence in Education (AIEd), as an interdisciplinary field, emphasize applying AI to assist instructor's assessment processes, empower student's learning process, and promote the transformation of educational system (Chen & Lin 2020). Artificial intelligence in education has the potential to enhance assessment practices and pedagogical development in the teaching processes by accessing students' performance automatically, monitoring and tracking students' learning (Berland, Baker & Blikstein, 2015; Duru, Uko, & Utibe, 2024), and predicting at-risk students (Hellings & Haelermans, 2020).

Furthermore, Artificial intelligence in Educational assessment is also beneficial for using assessment feedback to improve student-centered learning, such as providing adaptive tutoring (Kose & Arslan, 2017), recommending personalized learning resources (Ledesma & García, 2017), and diagnosing students' learning gaps (Liu *et al*., 2017). Artificial intelligence in Educational assessment also brings about opportunities to transform the educational system by highlighting the essential role of technology (Hwang, Xie &Wah, 2020), enriching the mediums of knowledge delivery (Holstein, McLaren & Aleven, 2019), and changing the instructor–student relationships (Xu & Ouyang, 2022). AI Technologies used in Education for transforming the teaching, learning and assessment practices can also be integrated into the field of science, technology, engineering and mathematics (STEM), the reason being that STEM is a sub-branch of Education. One area where AI has shown promising potential is in STEM (science, technology, engineering, and mathematics) education assessment practices.

The integration of AI technologies in assessment can help enhance the learning experience for students, provide personalized feedback, and improve teachers' ability to track and support students' progress effectively. AI technologies, such as machine learning algorithms, natural language processing, and data analytics, have been increasingly utilized in STEM education assessment practices. These technologies can automate the grading process, analyze students' responses, and provide real-time feedback to help identify areas for improvement. For example, adaptive learning platforms like Khan Academy and Duolingo use

AI algorithms to personalize learning pathways and assessments for students based on their individual strengths and weaknesses (Khan Academy, 2021; Duolingo, 2021).

While AI-driven assessments have shown promise in improving the efficiency and effectiveness of assessment practices in STEM education, there are challenges that need to be addressed. One key challenge is ensuring the reliability and validity of AI-generated assessment results. Educators and researchers must critically evaluate the algorithms and data sources used to ensure that AI assessments provide accurate and unbiased feedback to students. Additionally, ethical considerations around the use of AI in assessment practices, such as data privacy and security concerns, must be carefully addressed to safeguard students' personal information and ensure transparency in the assessment process. Implementing best practices for the design and implementation of AI-driven assessment criteria, providing opportunities for student reflection, and fostering a supportive learning environment, can help mitigate some of these challenges (Darabi, 2020).

Research on the impact of AI technologies in STEM education assessment practices has shown promising results in improving student learning outcomes. A study by Koedinger *et.al.* (2015) found that students who received adaptive feedback from an AI-powered tutoring system showed significant gains in learning outcomes compared to students who received traditional feedback. The personalized and timely feedback provided by AI technologies can help motivate students, enhance their understanding of STEM concepts, and improve their problem-solving skills. Several recent studies have been conducted on applications of Artificial Intelligence in many areas. For example, Liang *et al.*, (2021) focused on the application of AI in language education and investigated the roles and research foci (e.g., research methods, research sample groups) of AI techniques in language education and this study identified many AI techniques used in language education. Drigas and Ioannidou (2012) explored AIEd in special education and summarized AI applications based on the student's disorders, including reading, writing and spelling difficulties, dyslexia, autistic spectrum disorder among others. Richardson and Clesham (2021) also conducted a study on the evolving role of AI technologies in high-stakes assessment and the study identified several AI technologies used in assessment. These studies have shown that a lot of approaches and strategies have been put in place to integrate the field of Artificial intelligence in Education; however, what have been standing out are the advancements in Artificial Intelligence technologies and their application in the area of assessment practices in the field of science, technology, engineering and mathematics (STEM).

AI technologies can be deployed in the field of STEM education in areas of assessment. This is because it offers benefits over traditional assessment practices, such as immediate feedback, flexible access, rich multimedia resources, automatic grading, identifying at-risk students, and automatic performance assessment among others and these could enhance the assessment practices in STEM education and learning processes. There is a need to therefore

determine the advancements in AI technologies and the extent of their application in assessment practices in STEM education. It is on this note the study is set to be investigated.

**Purposes**

1. To determine the advancements in AI-STEM assessment technologies.
2. To determine the extent to which the advancements in AI technologies are applied in STEM Educational Assessment Practices.

**Research Questions**

1. What are the advancements in AI-STEM assessment technologies?
2. To what extent are the advancements in AI technologies applied in STEM Educational Assessment Practices?

**Methodology**

The study adopts a descriptive study design. This design permits the description of certain variables in relation to a population (Nworgu, 2015). Thus, it is considered most appropriate for this study as it allows the researcher to describe the application of advancements in AI technologies to STEM education. The study was carried out in the south-south region, Nigeria. The population for the study comprises 1249 Science Secondary School teachers in eleven public coeducational schools in south-south, Nigeria. Three hundred and fourteen (314) participants were estimated using Taro Yamane (1967) formula. Simple random sampling (tossing the dice) was used to draw the sample. This was to ensure that all participants had an equal chance of being drawn into the final sample.

AI advanced technologies in STEM education assessment practices questionnaire (AIATSEAPQ) instrument was developed by the researcher and used for the study. The instrument comprised 15 items with the response options on a 4-point Likert scale for cluster one to be strongly agreed (SA), agree (A), disagree(D) and strongly disagree (SD) and cluster two to be Very High Extent(VHE),High Extent(HE), Low Extent (LE), Very Low Extent(VLE), with numeric values of 4, 3, 2 and 1 respectively. The instrument was face validated by 3 experts. The instrument was trial tested on 30 teachers and the reliability coefficient of 0.70 and 0.74 was obtained for clusters 1 and 2 respectively using the Cronbach Alpha method.

The face-to-face method was employed in the collection of data to ensure a 100% return. Data was analyzed using mean and standard deviation. The real limits of numbers were used to interpret the results as follows; 3.50-4.00=Strongly Agree/ Very High Extent, 2.50-3.39=Agree/ High Extent, 1.50-2.49=Disagree/Low Extent, 0.00-1.49=Strongly Disagree/ Very Low Extent. The decision of the findings was guided by using a Mean score of 2.5 and above as a cut-off point as items being agreed to, while questionnaire items that fall below 2.5 were rejected.

**Results**

**Research Question 1:** What are the advancements in AI-STEM assessment technologies?

**Table 1: Mean responses for the advancements in AI-STEM assessment technologies**

| S/N | | N | Mean | SD | D |
|---|---|---|---|---|---|
| 1 | AI is used to incorporate gamification elements into assessment | 314 | 3.27 | 1.10 | A |
| 2 | Data analytics tools are used to analyze large datasets generated from student assessments | 314 | 3.99 | .76 | SA |
| 3 | AI-powered virtual laboratories are used by students to conduct experiments | 314 | 3.22 | 1.03 | A |
| 4 | Natural Language Processing are used to assess responses to open-ended questions | 314 | 3.17 | .95 | A |
| 5 | AI algorithms are used to analyze students' performance | 314 | 1.77 | .97 | D |
| 6 | Automated Grading Systems are used to automate grading process for assessments | 314 | 3.65 | 1.06 | SA |
| | **Cluster Analysis** | **314** | **3.22** | **.97** | **A** |

**Key: N= number of respondents, SD= standard deviation, D= decision**

The result in Table 1 shows the mean responses of science secondary school teachers on the advancements in AI-STEM assessment technologies. The respondents were asked to indicate the extent to which they agree or disagree to the items on advancements in AI-STEM assessment technologies and their uses in STEM education assessment practices. The analysis indicated that the respondents agreed to the identified advancements in AI-STEM assessment technologies, with a cluster mean of 3.22. The analysis further identified "AI algorithms used to analyze students' performance" as the least AI-STEM assessment technology with a mean of 1.77.

**Research Question 2:** To what extent are the advancements in AI technologies applied in STEM Educational Assessment Practices?

**Table 2: Mean responses for extent to which the advancements in AI technologies are applied in STEM Educational Assessment Practices**

| S/N | | N | Mean | SD | D |
|---|---|---|---|---|---|
| 1 | I use AI-driven assessment tools to automatically grade STEM assignments | 314 | 2.48 | 1.24 | LE |
| 2 | I use AI-driven assessment tools to provide feedback on STEM assignment | 314 | 1.95 | 1.15 | LE |

| | | | | | |
|---|---|---|---|---|---|
| 3 | I use AI algorithms to analyze my students' performance data in STEM education | 314 | 1.65 | .93 | LE |
| 4 | I use natural language processing to assess my student's responses to open-ended questions in STEM Education | 314 | 2.46 | 1.18 | LE |
| 5 | I use AI to incorporate gamification elements into STEM assessment | 314 | 3.02 | 1.00 | HE |
| 6 | I use Semantic analysis tools to understand my students' responses in open-ended questions in STEM assessment | 314 | 1.93 | 1.09 | LE |
| 7 | I use Computer vision technologies in assessing practical skills, in STEM education | 314 | 1.69 | .97 | LE |
| 8 | I use Intelligent tutoring systems to provide personalized feedback to my STEM students | 314 | 2.08 | 1.26 | LE |
| 9 | I use AI algorithms to provide standardized STEM assessment | 314 | 1.75 | .97 | LE |
| | **Cluster analysis** | **314** | **3.20** | **1.09** | **LE** |

**Key: N=number of respondent, SD= standard deviation, D= decision**

The result in Table 2 shows the mean responses for the extent to which the advancements in AI technologies are applied in STEM Educational Assessment Practices. The respondents were asked to indicate the extent to which the advancements in AI technologies are applied in STEM Educational Assessment by ticking the extent of application of each item provided. The analysis indicated that the respondents indicated a Low extent to AI technologies being applied in STEM Educational Assessment with a cluster mean of 3.20. The analysis further identified the "use of AI algorithms to analyze students' performance data in STEM education" as the lowest AI applied technology in STEM assessment with a mean of 1.65. It however, identified "use of AI to incorporate gamification elements into STEM assessment" as the highest AI applied technology in STEM assessment with a mean of 3.02.

**Discussion of Findings**

Table 1 shows the mean responses of science secondary school teachers on advancements in AI-STEM assessment technologies. The respondents expressed their agreement or disagreement with various statements related to the integration of AI in STEM assessment. The overall cluster mean of 3.22 suggests that, on average, the respondents tend to agree with the identified advancements of AI in STEM. Further analysis showed that Data Analytics Tools with Mean of 3.99 indicates that teachers strongly agree that data analytics tools are used to analyze large datasets generated from student assessments. Also, the use of

automated grading systems for assessments with mean of 3.65 received positive acknowledgment. The use of AI algorithms to analyze students' performance on the other hand, received the lowest mean with a mean of 1.65, indicating a comparatively lower level of agreement among respondents. The results therefore suggest a generally positive attitude toward the integration of AI-STEM assessment technologies in the assessment of STEM students.

The finding of this study is in line with the study by Richardson and Clesham (2021) that also identified several AI technologies used in assessment. The study is also in line with Liang et al., (2021) who also identified AI technologies used in language assessment. Hence, the finding of the study adds to empirical reports on the knowledge of teachers about advancements in AI-STEM assessment technologies.

Table 2 shows the extent to which advancements in AI technologies are applied in STEM educational assessment practices. The respondents provided mean responses indicating the extent to which the statements related to the application of AI in STEM assessment.

Further analysis indicated that the use of AI to incorporate gamification elements into STEM assessment had the highest mean of 3.02, which suggests a Very High Extent of its application among respondents. However, the use of AI algorithms to analyze students' performance data received the lowest mean of 1.65, indicating a low extent of application into STEM assessment. The overall Cluster Mean of 3.20 indicates that on average, the respondents indicated a low extent to which advancements in AI technologies are been applied in STEM educational assessment practices. The result suggests that AI technologies have not been adequately utilized in STEM assessment. Therefore, efforts should be made for the application of various AI technologies in the area of STEM assessment.

The findings of this study disagree with that of Dwivedi et al., (2021) who identified various application of AI in areas such as reading, writing, spelling difficulty detection among others. There seems to be a divergence of findings regarding the application of AI technologies in STEM educational assessment. Hence, the finding of the study adds to empirical reports that AI technologies have not been adequately utilized in STEM assessment practices.

**Conclusion:**

In line with the results obtained from this study, it is concluded that the advancements of artificial intelligence technologies are to a Low extent been applied in STEM assessment practices. Thus, there is a limited integration of AI advancements in evaluating and measuring student performance in science, technology, engineering, and mathematics fields.

**Recommendations**

The recommendations highlighted below are based on the findings of this study.

1. The ministry and relevant education stakeholders should promote awareness and training on AI-STEM Assessment Technologies by developing workshops, training

programs, or professional development sessions on enhancing teachers' understanding of advancements in AI-STEM assessment technologies.

2. Focus should be on educating teachers about the benefits of AI in STEM assessment, particularly emphasizing the positive aspects highlighted in the study, such as the strong agreement on the use of Data Analytics Tools and automated grading systems.
3. Adequate provision should be made for resources and support for teachers to effectively use the various AI technologies in STEM education.
4. Educational institutions, policymakers, and technology providers should Collaborate together to create initiatives and policies that support the effective integration of AI technologies in STEM education, to enhance innovation and improvement in assessment practices.

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