TEACHERS' KNOWLEDGE AND APPLICATION OF DIGITAL ASSESSMENT IN STEM EDUCATION

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Abstract

The study determined teachers' knowledge and application of digital assessment in STEM education. It was carried out in Nsukka Education Zone, Enugu State, Nigeria. Guided by four research questions, the study adopted descriptive survey design. The population of the study included all 220 STEM teachers (Chemistry, Physics, Biology and Mathematics teachers) in the education zone. Multistage sampling procedure was then used to sample STEM teachers from the three LGAs which make up the zone. The sample size for the study was 88 STEM teachers, determined through the Taro Yamane sampling formula. Teachers' knowledge and application of digital assessment questionnaire, developed by the researchers,was used to collect data for the study. Data collected were analysed using SPSS 25 version. Frequency, Mean and Standard deviation was used to answer the research questions posed to guide the study. Findings revealed that STEM teachers were not aware of most digital assessment tools but applied the ones they know to a low extent in STEM teaching. The study hence concluded that there was a low level of teachers' knowledge and application of digital assessment tools. The study recommended that in-service training be organized for STEM teachers in order to improve the trend and to keep abreast with modern digital assessment tools.

Keywords: Teachers' Knowledge, Application of Digital Assessment, Technology, STEM, Education

Introduction

Educational system today is greatly experiencing changes with the advent of digital assessment tools. Education, and particularly Science, Technology, Engineering and Mathematics (STEM) education, plays a crucial role in achieving the Sustainable Development Goals (SDGs). STEM is an accumulation of the knowledge components of sciences, mathematics, engineering and technology, which have become inextricably linked. STEM education seeks to elaborate and provide innovative solutions to solve global issues. The use of scientific knowledge to develop innovative programs is a unique feature of modern science programs taught in schools today. In the report of Care, Griffin, and Wilson (2018) posit that educational institutions are required for innovation in order to facilitate students to have the skills

needed for the 21st century. Skills required in carrying out STEM-related tasks include cognitive, manipulative, technological, collaborative and communicative skills. STEM education is transmitted by teachers who are trained in STEM fields at different levels of education.

STEM education is one of the most prominent educational initiatives in the 21st century (Huang, et al., 2022). As STEM education responds to societal needs, values and concerns, it is important to develop a rounded understanding of STEM philosophy and practice. The core feature of STEM is the use of science, mathematical, technical, engineering knowledge to solve daily or societal problems, making the learning of science, technology, engineering and mathematics more meaningful and contextual. STEM literacy has been defined by Bybee (2013) as:

i. Knowledge, attitudes, skills [and values] to identify questions and problems in life situations. Explain the natural and designed world, and draw evidence-based conclusions about STEM related issues;
ii. Understanding of the characteristic features of STEM disciplines as forms of human knowledge, inquiry, and design;
iii. Awareness of how STEM disciplines shape our material, intellectual, and cultural environments; and
iv. Willingness to engage in STEM-related issues with the ideas of science, technology, engineering, and mathematics as a constructive, concerned and reflective citizen.

In the fast-changing world, with technology evolving at an unprecedented pace, competence is conceptualized as a developmental capacity rather than as a set of fixed skills (Marope, 2017). STEM competence as viewed by Zhang, et al., (2022) refers to an individual's ability to apply STEM knowledge, skills and attitude appropriately in his or her everyday life, workplace or educational context. It should not be confined and developed within the traditional boundaries of discrete bodies of knowledge (e.g. physics competence or computing competence). STEM competence covers both the 'know-what' (the knowledge, attitudes and values associated with the disciplines) and the 'know-how' (the skills to apply that knowledge, taking account of ethical attitudes and values in order to act appropriately and effectively in a given context).

With the increasing populace that seems to be unstoppable, the expansion of STEM into facets of society is the development that researchers and policy makers have been working tirelessly to incorporate in our educational system. Evident to this report, Havice (2015) mention that the job market has experienced an unprecedented demand for individuals with training and skill in STEM related fields. Wherefore, in order to maximize the effectiveness of STEM, early interventions are vital and should also be considered when implementing integrated STEM Learning.

STEM education in the 21st century Nigeria is no more regarded as a story tale; it has been existing in this era for long; though teachers' applicability is not fully ascertained. It integrates four disciplines, namely: Science, technology, engineering and mathematics. Cooper and Heaverlo, (2013) pointed out that the 21st century is a

technological age STEM education play an important role in shaping the culture and economic development with a viewpoint of innovativeness, creativity and problem solving. According to Sari, Alici, and Sen, (2017), many researchers argue that STEM instruction contribute to the national economy and educators attempt to develop integrated instructional programs. STEM education has benefits for students, such as increasing academic achievement in science and mathematics (Kartal&Tasdemir, 2021), improving attitudes, motivation, and interest toward STEM disciplines (Kartal&Tasdemir, 2021), promoting conceptual understanding (Margot &Kettler, 2019), and improving higher-order thinking skills and technological literacy (Aldahmash et al., 2019).

STEM education is also a learning approach that removes the traditional barriers that separate science, technology, engineering, and mathematics from each other and integrates them into students' learning experiences (Vasquez, et al, 2013). The success of STEM education is influenced by how it's been implemented within the framework of the learning model. To determine how successful STEM education has been, students going through the program need to be assessed in line with the program objectives as well as expected learning outcomes. Assessment is a vital element of the teaching and learning process, as it provides a means via which the teacher determines which stated educational objectives have been achieved. "Assessment is essential not only to guide the development of individual students, but also to monitor and continuously improve the quality of programmes, inform prospective students and their parents. It also provides evidence of accountability to sponsors of education" (Obikeze,Ifeakor, Akujieze, Anujeonye, 2019:234). Assessment is more broadly defined as the processes used of determining students' achievement status, with reference to learning objectives, considered as expected learning outcomes (Anikweze, 2014). A teacher thus states expected learning outcomes as learning objectives for each lesson, and the only way to determine how much learning has taken place is by assessing students.

The advancements in technology has significantly reshaped the assessment and testing landscape. The introduction of technology into the teaching and learning process, has altered testing paradigm, and precipitated a transition from Paper-Pencil Test (PPT) to digital assessment(Oladele, 2020). According to Haleem et al. (2022), digital assessment refers to the use of digital tools, technologies, and platforms to evaluate students' knowledge, skills, and performance in science, technology, engineering, and mathematics disciplines. It encompasses a wide range of assessment methods, including online quizzes, virtual simulations, coding projects, data analysis, and multimedia presentations(Grosseck et al., 2024). This form of assessment provides immense benefits to STEM education, including enhanced authenticity, immediate feedback, personalized learning, flexibility, adaptability, and improved data analysis(Hooda et al., 2022). These advantages contribute to more engaging, relevant, and effective assessment practices in STEM disciplines.

The advantages of digital assessment are so numerous among them are:Digital assessment provides opportunities for students to engage in authentic, real-world

tasks that mirror the practices of STEM professionals. According to National Research Council. (2012), digital assessments can simulate scientific experiments, engineering design challenges, and data analysis scenarios, enabling students to apply their knowledge and skills in practical contexts. This authenticity enhances the relevance of assessment tasks and promotes deeper understanding of STEM concepts(McArthur, 2022). Digital assessment tools often offer immediate feedback, allowing students to receive timely information about their performance. This aspect of digital assessment supports formative assessment practices, enabling students to identify their own strengths and weaknesses and make adjustments accordingly(Ozan&Kıncal, 2018). As stated by Gulikers, Bastiaens, and Kirschner (2004), timely feedback is essential for students' self-regulation and metacognitive development, leading to improved learning outcomes.

Digital assessment also provides flexibility in terms of time, location, and individual pacing. Students can access and complete assessments at their own convenience, which is particularly beneficial for asynchronous or online STEM courses(Tong et al., 2022). Additionally, digital assessments can be adaptive, tailoring the difficulty level and content based on individual student performance. This adaptability supports personalized learning and accommodates diverse student needs (Martin, 2012). Digital assessment platforms generate rich data on student performance, allowing educators to analyze and gain insights into students' learning patterns, misconceptions, and progress. The analysis of these data can inform instructional decision-making, curriculum design, and intervention strategies. According to Pellegrino et al. (2001), digital assessment offers the potential for more comprehensive and detailed data collection, enabling educators to make more informed assessments of student achievement and guide their learning effectively. Some digital assessment tools include:Hurix, Socrative, Mentimeter, Poll Everywhere, Kahoot, Quizlet, Thinglink, TestGorilla, Google Forms, and Moodle (Harve, 2023).

Hurix is a digital assessment tool offering a comprehensive online assessment and evaluation platform. The platform is designed for K-12 schools, higher education institutions, and corporate training providers.It allows teachers and trainers to create, deliver, and grade assessments online. In addition, the platform allows you to create various question types, including multiple-choice, true or false, and short-answer questions(Harman, 2024).Socrative is a digital assessment tool for teachers, crafted to help them create and deliver assessments in real time. The tool is designed for K-12 classrooms and higher education institutions, offering a variety of question types, including multiple-choice, true or false, and short-answer questions(Suryani&Fauziati, 2022).Mentimeter is another essentially an interactive presentation tool that also offers features to create engaging and interactive assessments. The platform offers a variety of question types, including multiple-choice, true or false, and open-ended questions.The tool also provides real-time analytics and reporting features that allow teachers to track student progress and performance(Mohin et al., 2024).

Poll Everywhere is a web-based tool that allows users to create live polls, quizzes, and surveys to engage students in real time. It supports various questions, including multiple-choice, open-ended, and rating scales(Castillo et al., 2020).Students can participate in polls using their smartphones, tablets, or laptops; results are instantly displayed on the teacher's screen. The app can also be integrated with various learning management systems (LMS) and presentation software, such as PowerPoint and Google Slides.Kahootis a game-based learning platform for teachers and students. It enables teachers to create engaging assessments and quizzes, which can include various question types, including multiple-choice, true or false, and open-ended questions(Wang & Tahir, 2020).The game-based learning activities help students to learn and retain information in a fun and engaging way.Quizlet is a free-to-use learning platform that's targeted toward making learning fun and interactive. It offers a range of assessment and evaluation tools that allow teachers to create engaging and interactive assessments for their students(Neendoor, 2023).The best part of the platform is its ready-to-use Quizlet Solutions section for popular textbooks, which students can use to get additional information on a particular topic.

Thinglink is a digital tool that allows teachers to create interactive images and videos for their students. It provides various multimedia options, including text, images, audio, and video, that can be embedded within an image or video(Chauhan, 2018).TestGorilla is a well-known online platform that provides pre-employment testing and employee assessments. It includes a library of over 200 pre-built assessments covering various topics such as cognitive ability, personality, and job-specific skills(Neendoor, 2023).Google Forms is a simple and intuitive tool allows teachers to create and deliver assessments online.The platform offers a variety of question types, including multiple-choice, true or false, and open-ended questions. Google Forms also provides real-time analytics and reporting features that allow teachers to track student progress and performance.Moodle is an open-source learning management system (LMS) that provides a platform for creating and delivering online courses. It includes various assessment tools, such as quizzes, assignments, and workshops that allow teachers to evaluate students' performance(Neendoor, 2023). In addition, the platform supports multiple question types, including multiple-choice, true/false, and essay questions.

Teachers need to have a solid understanding of digital assessment methods, tools, and technologies to effectively integrate them into STEM instruction. This knowledge includes familiarity with various digital assessment platforms, data analysis techniques, and strategies for providing meaningful feedback. According to Voogt et al. (2013), teachers should possess the pedagogical knowledge necessary to align digital assessment with learning objectives, select appropriate assessment methods, and apply digital assessment tools into STEM teaching and learning. Teachers' application of digital assessment in STEM education involves several key aspects:

i. Task Design and Selection: Teachers need to design or select digital assessment tasks that align with STEM learning objectives and provide authentic

opportunities for students to apply their knowledge and skills. These tasks may include simulations, coding projects, data analysis tasks, or multimedia presentations. It is important for teachers to consider the suitability of different digital tools and platforms to support these tasks (Penuel et al., 2016).

ii. Technology Integration: Teachers should be proficient in using digital assessment tools and technologies to administer assessments effectively. This includes setting up and managing digital assessment platforms, ensuring reliable internet connectivity, and troubleshooting technical issues. Additionally, teachers need to provide clear instructions and guidelines to students on how to access and complete digital assessments (Chen & Chung, 2018).

iii. Data Analysis and Feedback: Teachers should be able to analyze the data generated by digital assessments to gain insights into student performance and progress. This involves interpreting assessment results, identifying student misconceptions or areas of improvement, and providing timely and constructive feedback to support student learning (Herold, 2016). Teachers can utilize data visualization tools or learning analytics platforms to aid in this process.

iv. Differentiation and Personalization: Digital assessment allows teachers to tailor assessments to meet the diverse needs of students in STEM education. Teachers can use adaptive assessment platforms to customize the difficulty level or content of assessments based on individual student performance. They can also provide differentiated feedback or design alternative assessments to cater to students' varied interests, learning styles, or abilities (Cavanaugh et al., 2014).

Teachers' knowledge and application of digital assessment are pivotal in STEM education. Teachers must possess a solid understanding of digital assessment methods and tools, integrating technology seamlessly into their instructional practices(Davidson et al., 2014). By effectively utilizing digital assessment, teachers can enhance the authenticity and relevance of assessments, provide immediate feedback, and tailor instruction to meet the diverse needs of students(Mate &Weidenhofer, 2021). Through their expertise in digital assessment, teachers empower students to excel in STEM education and prepare them for the challenges of the modern world.

Studies have explored teachers' perceptions and experiences with digital assessment in STEM education, revealing both potential and challenges. Some research like Yıldırım (2021) suggests a positive outlook on digital assessment, highlighting its ability to measure a wider range of skills compared to traditional methods. Additionally, (Elmahdi et al., 2018) reported that digital tools can provide real-time feedback and facilitate formative assessment, allowing for adjustments in instruction based on student needs. However, other studies like ((Thorvaldsen & Madsen, 2021; Yavich&Davidovitch, 2021) indicate a gap between teachers' attitudes and their actual use of digital assessment. Factors like limited professional development and technical difficulties can hinder effective implementation (Beames et al., 2020). There is a particular lack of research investigating teachers' knowledge and application of digital assessment in the context of the Nsukka education zone of

Enugu State, Nigeria. This gap necessitates further exploration to understand the specific needs and challenges faced by educators in this region. By examining teachers' experiences in Nsukka, we can gain valuable insights into how to best support them in utilizing digital assessment tools to enhance STEM education.This study therefore x-rayed the level of teachers' knowledge and extent of application of digital assessment in STEM education. To achieve this, the study was designed to answer the following questions:

1. To what extent are STEM teachers aware of digital assessment tools?
2. To what extent do teachers apply digital assessment in STEM teaching?
3. What factors influence teachers' application of digital assessment in STEM teaching?
4. What strategies can be adopted to improve teachers' application of digital assessment in STEM teaching?

Methodology

The design adopted for this research work is the descriptive survey. Descriptive survey according to Nworgu (2015) is one in which a selected portion of a population is studied as a representative of the entire population in order to provide information about the naturally occurring characteristics of a particular group of people it seeks to study. The study was carried out in Nsukka Education Zone. The zone comprisedcomprises three LGAs – Nsukka, Uzo-Uwani, and Igbo-Etiti. The area comprisedof 62 public secondary schools, including co-educational and same sex schools. The population of the study comprised all 220 (93 males and 127 females) science teachers in public secondary schools in Nsukka Education zone. This population includes 127, 48 and 45 science teachers from Nsukka, Igbo-Eititi and Uzo-Uwani LGAs respectively (Statistics Unit, PPSMB Nsukka Education Zonal Office, 2022/2023 academic session). The sample size for the study will be 88 science teachers in Nsukka education zone. Multistage sampling procedure will be used to select the 88 science teachers whotookpart in the study. First, proportionate stratified sampling technique was used to determine the proportion of teachers who were sampled from each LGA in the zone. Proportionate stratified sampling ensures that each stratum of a population is adequately representedin the study. Each LGA in Nsukka education zone was therefore treated as a stratum. Simple random sampling technique was then used to select 51, 19 and 18 science teachers from Nsukka, Igbo-Etiti and Uzo-Uwani LGAs respectively. The instrument for data collection is questionnaire developed by the researchers and titled “teachers' knowledge and application of digital assessment questionnaire.” The questionnaire consisted offour clusters, all with a four-point Likert scale response option, designed to elicit data to answer the research questions posed in the study. The instrument was validated (face and content validation) by three expertsin the measurement and evaluation unit of University of Nigeria Nsukka and the reliability of the instrument(measure of internal consistency) was determined through Cronbach Alpha reliability index to be 0.84. The questionnairewas distributed by the researchers to teachers in their respective

schools after obtaining permission from their school heads and collected on the spot for analysis. Data was analysed using IBM SPSS 25 versionand interpreted using, mean and standard deviation. A criterion mean of 2.50was adopted to interpret the output from analysis. The criterion mean was determined from averaging the four response options of strongly agree/very high extent (4), agree/high extent (3), disagree/low extent (2) and strongly disagree/very low extent (1).

Results

Findings from analysis of collected data are presented in tables in line with research questions posed to guide the study.

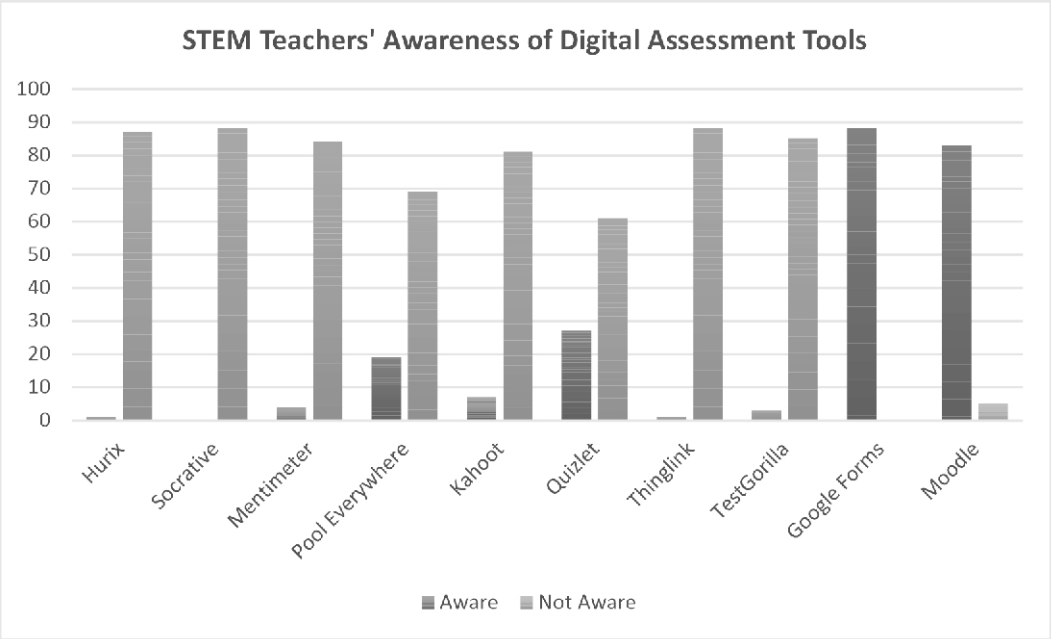

Figure 1: STEM Teachers' Awareness of Digital Assessment Tools

The figure above shows that STEM teachers are only aware of two digital assessment platforms/tools – Moodle and Google forms. All other digital assessment tools are not popular among STEM teachers in the area.

Table 1: Extent to which STEM Teachers Apply Digital Assessment Tools

S/N	Digital Assessment Tools	N	??	SD	Decision
1.	Hurix	88	1.60	.60	Low Extent
2.	Socrative	88	1.80	.75	Low Extent
3.	Mentimeter	88	1.00	.78	Low Extent
4.	Pool Everywhere	88	1.10	.71	Low Extent
5.	Kahoot	88	1.50	.68	Low Extent
6.	Quizlet	88	1.10	.75	Low Extent
7.	Thinglink	88	1.04	.71	Low Extent
8.	TestGorilla	88	1.20	.88	Low Extent
9.	Google Forms	88	1.90	.71	Low Extent
10.	Moodle	88	2.00	.45	Low Extent
	Cluster Mean		**1.42**	**0.70**	**Low Extent**

Result in table 1 shows that all digital assessment tools presented in the table are applied by STEM teachers in teaching to a low extent since the cluster mean is 1.42 and it is below the benchmark mean of 2.50. The standard deviation of 0.70 islowindicatingthatthere is a variation in the responses of teachers.

Table 2: Factors Influencing Teachers' Application of Digital Assessment in STEM Teaching.

S/N	Item Statement	N	??	SD	Decision
1.	Lack of knowledge of digital assessment	88	3.10	.54	Agree
2.	Lack of skills to utilize digital assessment	88	2.40	.92	Agree
3.	Lack of facilities to utilize digital assessment tools	88	2.50	.68	Agree
4.	Poor attitude towards digital assessment	88	3.10	.71	Agree
5.	Shortage of time to implement digital assessment	88	2.70	.64	Agree
6.	Student apathy towards digital assessment	88	3.20	.75	Agree
7.	Lack of skills among students to use digital assessment	88	2.80	.60	Agree
	Cluster Mean		**2.83**	**0.69**	**Agree**

Table 2 shows that respondents agreed to all items in the table with mean ratings ($\overline{X}$=2.83) greater than 2.50 criterion mean. This shows that Lack of knowledge of digital assessment, lack of skills to utilize digital assessment, lack of facilities to utilize digital assessment tools, poor attitude towards digital assessment, shortage of

time to implement digital assessment, student apathy towards digital assessment, and lack of skills among students to use digital assessment. The SD of 0.69 indicates similarity in the responses of the teachers

Table 3: Strategies can be Adopted to Improve Teachers' Application of Digital Assessment in STEM Teaching.

S/N	Item Statement	N	??	SD	Decision
1.	Provide in-service training for STEM teachers	88	3.10	.40	Agree
2.	Recruit only teachers who possess the skills to use digital assessment	88	3.50	.12	Agree
3.	Provision of facilities to foster utilization of digital assessment	88	3.15	.42	Agree
4.	Sensitize STEM teachers on the benefits of using digital assessment tools	88	3.70	.10	Agree
5.	Equipping students with skills to use digital assessment tools	88	2.90	.24	Agree
	Cluster Mean		**3.27**	**0.26**	**Agree**

The Table3 shows that respondents agreed to all items as representing strategies that can improve the application of digital assessment in STEM teaching since their cluster mean value of 3.27 is higher than the benchmark mean of 2.50. More, the cluster SD of 0.26 implies that there is a low variation in the responses of the teachers

Discussion of Findings

The findings showedthat STEM teachers are not aware of modern digital assessment tools. Only digital assessment tools are slightly known to STEM teachers and these are the Google Forms and Moodle. Google forms are typically popular among STEM teachers in the area because University lecturers in Nsukka utilize this tool to collect data for their empirical researches. Also, Moodle is used in the University of Nigeria Nsukka and some private secondary schools in the area to teach students. The utilization of these tools could have familiarized STEM teachers in the area about them, hence their being aware of it. Also, Moodle and Google forms are common because they are used in tertiary institutions in Nigeria as STEM teachers pass through these institutions during their training, they hear about these platforms and sometimes see their lecturers use them. The teachers however appear to be unware of other digital assessment tools like Hurix, Socrative, Mentimeter, Pool Everywhere, Kahoot, Quizlet, Thinglink, and Test Gorilla. This could be due to a lack of exposure or professional development opportunities focused on exploring a wider range of digital assessment platforms.

Additionally, factors like teacher comfort level with technology and potential resource constraints in schools might contribute to the continued reliance on familiar tools.The teachers also do not utilize any of these platforms for assessment at the

secondary school level, citing several reasons like of access and facilities to utilize them. These corroborates the assertions of Adebunmi&Ayodele (2021) and Nguyen&Habok (2023), who posit that digital assessment platforms are novel to secondary school teachers and are seldom used at that level in Nigeria. Other factors that impact utilization of digital assessment tools are insufficient knowledge and skills, lack of facilities, teachers' attitude and shortage of time. If teachers are not aware of the various tools available, they cannot explore options that might better suit their teaching needs and assessment goals.Even if teachers are aware of tools, a lack of proper training or experience can make them hesitant to implement them effectively in the classroom, leading to continued reliance on traditional methods.Limited access to computers, internet connectivity, or appropriate devices in schools can create a significant barrier for both teachers who want to use digital assessments and students who need to take them.Some teachers might hold negative beliefs about the effectiveness or value of digital assessments, making them resistant to adopting them in their teaching practice.Creating, administering, and grading digital assessments can be time-consuming. If teachers already feel overwhelmed with their workload, they might be less likely to invest the time in learning and using new tools.

Conclusion

STEM education is important to national and global development. For her lofty objectives to be achieved, STEM teachers have to regularly assess their teaching of STEM subjects to get feedback with which to re-evaluate their teaching methods. Digital assessment is the convention in modern education and as Nigerian education evolves, the country needs to transition from traditional forms of assessment to digitized forms because of the gains derivable from them.

Recommendations

The study recommends that:

1. In-service training be organized by school administrators for their STEM teachers on the skills for using digital assessment tools.
2. School administrators should furnish their schools with ICT facilities to help teachers use digital assessment platforms.
3. Knowledge of digital assessment platforms should be made a qualification requirement for recruitment of new STEM teachers.
4. General awareness campaigns should be organized in schools to sensitize STEM students and teachers on the benefits of digital assessment platforms.

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