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International Journal of Education, Technology and Science
5(2) (2025) 209–223

IJETS
International Journal of Education Technology and Science

USE OF DIGITALIZATION IN SCIENCE EDUCATION: A CASE STUDY OF STEM TEACHERS IN THE IBADAN METROPOLIS, NIGERIA

(Research article)

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Received: 29.01.2025 Revised version received: 10.03.2025 Accepted:14.03.2025

Abstract

Digitalization promotes the attainment of the Sustainable Development Goals concerning education and has shown potential for advancing STEM teaching and learning. Hence, there is a need for its integration in every science classroom. This study investigated the extent to which digitalization is implemented in secondary schools in the Ibadan metropolis. This study also garnered the challenges in integrating digital technologies and suggested possible interventions. Anchored to Rogers's Diffusion of Innovation Theory, this study adopted the descriptive survey design. The participants were composed of randomly selected 103 STEM instructors from 15 public schools within three local government areas out of five local government areas in the Ibadan metropolis. Science Teachers' Utilization of Digitalization Questionnaire (STUDQ)was properly validated using Cronbach Alpha ($\alpha = 0.89$), and was used to collect data. The data were analyzed using descriptive and inferential statistics (ANOVA). The findings have revealed that science teachers in Ibadan use digitalization to some extent, in the classroom. In addition, the attendant challenges in using digitalization include a lack of technical capacity, a lack of students' access to digital tools, and funding issues. These issues are experienced, regardless of the teacher's subject area. It was concluded that digital technologies are inadequately utilized. Therefore, to foster sustainability in STEM education and improve learning outcomes, teachers should be trained to acquire the required skills. It was recommended that the government should increase funding to organize regular training workshops and seminars for STEM teachers with necessary digital skills and to support the procurement of digital tools for schools.

Keywords: Science education; digitalization; STEM teachers; learning outcomes

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DOI: https://doi.org/10.5281/zenodo.15499135

1. Introduction

1.1. Background to the study

Science and its applications have evolved and translated into technological inventions. In Nigeria, the development of Science, Technology, Engineering, and Mathematics (STEM) education is a description of a gradual process amid challenges and opportunities. STEM education refers to teaching and learning in science, technology, engineering, and mathematics. Its beginning in Nigeria is pinned to the government's recognition of these fields' pivotal role in economic and national growth (Agboola, 2021).

Furthermore, the 2002 World Summit on Sustainable Development (WSSD) confirmed STEM's significant role in facilitating sustainable national economic growth (Okorafor, Kakiri, and Okorafor, 2015). According to Freeman et al., (2019); Umar, (2019), STEM education plays a crucial role in national development, economic growth, and societal well-being. Aina (2022) provides a critical perspective on the trajectory of STEM education in Nigeria, stating its contributions to various sectors such as health, agriculture, and telecommunication. According to Umar (2019), African leaders must realize that science and technology are crucial to the sustainable growth and economic transformation of any country. Also, it has been emphasized that effective and quality teaching, research, innovation, policies, and problem-solving all require and make use of STEM education.

Among the myriads of issues in STEM education, are pedagogical, curriculum integration, and student-related problems (Salvetti et al., 2023). Others include heavy workloads, gender, language, insufficient learning aids, poor funding, and lack of creativity (Umar, 2019; Freeman et al., 2019; Kehdinga, 2019), Agboola, 2021). To address these challenges, scholars have recommended the improvement of resource utilization and teachers' capacity building; emphasizing effective STEM pedagogy, and utilizing design thinking approaches (Salvetti et al., 2023; Öztürk, 2021). Effective STEM pedagogy can be achieved by creating innovative learning environments and promoting collaboration, and inclusivity (Salvetti et al., 2023; Suhirman and Prayogi, 2023). There is a notion that integrating technological and inquiry-based environments can facilitate students' problem-solving abilities. (Sahito and Wassan, 2024). One such environment is characterized by digitalization.

Digitalization entails the physical processes that enable adaptation to digital technologies. It involves linking instruments, integrating software and data, matching processes and workflows, and fitting in other laboratory components to achieve a complete digital transformation. In simpler terms, digitalization is the utilization of digital technology to collect data, set trends, mechanize processes, and get improved professional results. According to

Hazarika (2020), digitalization is the most significant technological trend that is transforming both, society and business and there is a constant drive to adapt to its demands as it gains more attention among intellectuals (Parviainen, Tihinen, and Kääriäinen, 2017; Betkovský, Rózsa and Mulyaningsih, 2018; Kohli and Melville, 2019). Interestingly, the unprecedented COVID-19 pandemic accelerated the adoption of digital learning (Macan et al., 2022).

As a multifaceted concept, digitalization may include text, image, sound, video, and data digitalization. These are applied as learning technologies, software, apps, computer programs, simulations, virtual laboratories, and social media. The outcome of digitalization in STEM education is seen in the various approaches and tools. Three popular types of digital tools used in STEM classes are instrumental, computer simulation, and modern technologies like VR, AR, AI, and 3D modeling (Shapovalov et al., 2023).

1.2 Literature Review

Digital tools in STEM education can enhance both scientific and digital competencies, contributing to students' personal and professional development in the digital era (Valarezo et al., 2020) while improving their competencies, motivation, creativity, and problem-solving skills (Khalid et al., 2025). No doubt incorporating digital tools in STEM education can increase efficiency, make learning more engaging, and support inquiry-based learning. A similar study by Mittal et al., (2018) showed that digitalization provides unprecedented access to knowledge, reduced costs, and greater interdisciplinarity, which is also a necessity. Abiodun et al., (2023) described digitalization as a “powerful tool” for teaching mathematics in the post-primary school.

Furthermore, Sam-Kayode et al., (2023), observed that science teachers in Nigeria possess basic digital literacy skills. Still, they face challenges such as limited access to digital tools and inadequate technical capacity. This was buttressed by the findings of Onyema (2020) who drew responses from 200 teachers and students from secondary and tertiary schools in southwestern Nigeria, on the integration of emerging technologies into education. A comprehensive analysis of the data showed that the attendant challenges include the insufficiency of digital skills, funding, internet, and power supply.

In another clime, a systematic review revealed that digital education in science teaching is hampered by technical difficulties and a lack of teacher training (Nor and Halim, 2023). However, teachers generally have positive perceptions towards digital technologies, recognizing their potential to enhance student motivation and learning experiences (Abiodun et al., 2023; Althubyani, 2024). Pre-service teachers in South Africa expressed favorable views on digital game-based learning for STEM education, emphasizing its ability to provide

diverse learning opportunities and promote contextualized learning (Gumbi et al., 2024). These findings underscore the need for equitable distribution of digital facilities, continuous professional development for teachers, and strategies to overcome implementation challenges to integrate digital technologies in science education effectively (Abiodun et al., 2023).

Generally, integrating digitalization in science lessons can enable teachers to deliver instruction effectively, encourage participation and inclusion, sustain collaborations, provide opportunities for students' inventiveness, increase learning interest, demystify difficult concepts, and reduce anxiety (Onyema, 2020; Khalid et al., 2025). Timotheou et al. (2023) emphasized the integration of ICT in STEM education to enhance digital capacity. Borisenkov et al. (2021) discussed the need for personalized and targeted teacher training to improve digital competence. Vidal-Esteve and Martín-Gómez (2023) compared perceptions of digital tool usage in different educational contexts, highlighting disparities. Pozo et al. (2024) found that experienced teachers increasingly adopt digital tools for student-centered activities, emphasizing the importance of prior experience. Although these numerous benefits are encapsulated in the use of digitalization in science education, its successful implementation requires a synergic system among key stakeholders (Hrynevych et al., 2021).

The findings of this study would be of significant to the growing body of research on digitalization, particularly in STEM teaching in Nigeria. Previous studies explored the adoption of digital tools in Education. This study focuses specifically on teachers' awareness of digitalization and identifies key challenges that hinder effective integration of digitalization in classrooms. It would also provide a better understanding of the challenges faced by STEM teachers in a resource-constrained setting. This study therefore investigated the use of digitalization among STEM educators in the Ibadan Metropolis, Nigeria.

1.3 Theoretical Framework

This study is anchored to the Diffusion of Innovations theory postulated by Everett Rogers (2003). According to Rogers, DOI represents the process through which an individual move from first knowledge of an innovation towards forming an attitude to it to a decision to adopt or reject it, to implementation of the new idea, and confirmation of this decision. The innovation-decision process includes five phases (Rogers, 2003). The first addresses knowledge, when the individual is exposed to the innovation's presence and understands how it works. This is followed by persuasion when the individual creates a favorable or unfavorable attitude towards the innovation. At the point of decision, the individual gets engaged in activities that result in a choice to adopt or reject the innovation. The penultimate stage is that of implementation when the individual puts the innovation to use. Confirmation is the point when the individual seeks reinforcement for an innovation decision already made.

In the context of digitalization in science education, the Diffusion of Innovations theory can be applied to understand how digital tools and technologies are adopted and implemented in educational settings. It highlights the need for effective communication, teacher training, and support to facilitate the adoption and integration of digital technologies in science education. By understanding the attributes that influence the rate of adoption and the tiered sequence of adoption, educators and policymakers can design strategies to promote the effective use of digitalization in science education.

1.4 ***Objectives of the Study***

1. To examine the extent do STEM teachers utilize digital tools in their teaching
2. To examine the primary challenges preventing STEM teachers from effectively integrating digital tools in their class

1.5 ***Research Questions***

1. To what extent do STEM teachers utilize digital tools in their teaching?
2. What are the primary challenges preventing STEM teachers from effectively integrating digital tools in their class?

1.6 ***Research Hypotheses***

Ho1. There is no significant difference between teachers' subject areas and their utilization of digital tools?

Ho2. There is no significant difference between teachers' subject areas and challenges faced by STEM teachers in effectively integrating digital tools in their classroom?

2. Method

2.1 Research Design

This study adopted the descriptive survey design. Descriptive research is a research method used to try and determine the characteristics of a population or particular phenomenon (Shinija, 2024). Two research questions were answered and two corresponding hypotheses were tested at a 0.05 significant level.

2.2 Sampling technique

103 STEM instructors (Biology, Chemistry, and Physics teachers) were sampled from 15 public schools within three randomly selected local government areas out of five local government areas in the Ibadan metropolis. The 39-item, 4-point Likert Scale (Science Teachers' Utilization of Digitalization Questionnaire (STUDQ) was constructed by the researcher drawing from the five (5) principles of the DOI theory, which are; relative advantage, compatibility, complexity, trialability, and observability. The choice of DOI theory as a framework for this study is because it helps to understand the process of adoption of

innovations, including the stages of awareness, persuasion, decision, implementation, and confirmation.

2.3 Validation of Instrument

The STUDQ was properly validated by related scholars who scrutinized the instrument for content and face appropriateness. Their remarks were used to make changes to the instrument. The STUDQ was pilot tested using 20 STEM instructors who are not part of the main study. The reliability measure was determined using the Cronbach Alpha and the reliability coefficient obtained was 0.89.

2.4 Data Analysis

Data was then collected and analyzed using descriptive (mean, standard deviation, and percentages) and inferential statistics (ANOVA).

3. Results

Research Question 1: To what extent do STEM teachers utilize digital tools in their teaching?

Table 1: STEM Teachers' Levels of Utilization of Digitalization

S/N		SA	A	D	SD	Mean	Std.
1	I am very familiar with educational software such as MATLAB, PHeT simulations, etc.	24 23.3%	33 32%	31 30.1%	15 14.6%	2.64	1.00
2	I often include online resources in my lessons	28 27.2%	43 41.7%	19 18.4%	13 12.6%	2.83	0.97
3	Digital tools are not available in the school I teach	24 23.3%	24 23.3%	44 42.7%	11 10.7%	2.59	0.96
4	I communicate with students using social media such as WhatsApp, Facebook, and Google Classroom	19 8.4%	15 14.6%	47 45.6%	22 21.4%	2.30	1.00
5	I have used interactive whiteboards for my teaching	32 31.1%	23 22.3%	25 24.3%	23 22.3%	2.62	1.15
6	I have not used educational apps in teaching	16 5.5%	20 19.4%	44 42.7%	23 22.3%	2.28	0.98
7	I have digital textbooks in my device for teaching science concepts	31 30.1%	27 26.2%	33 32%	12 11.7%	2.75	1.02

8	I have a computer (laptop, desktop, tablet)	41 39.8%	33 32%	18 17.5%	11 10.7%	3.01	1.00
9	I think that smartphones and other digital tools are too expensive	35 34%	27 26.2%	21 20.4%	20 19.4%	2.75	1.13
10	I have access to the internet	52 50.5%	29 28.2%	12 11.7%	10 9.7%	3.19	0.99
11	I have never used a projector for teaching science	33 32%	34 33%	19 18.4%	17 16.5%	2.81	1.07
12	I often conduct assessment tests online	17 16.5	23 22.3%	30 29.1%	33 32%	2.23	1.08
13	I often use YouTube videos and cartoons to facilitate my students' understanding of science concepts	22 21.4%	28 27.2%	28 27.2%	25 24.3%	2.46	1.08
14	I use digital tools such as simulations to help my students who have some difficulties in engagement	19 18.4%	25 24.3%	37 35.9%	22 21.4%	2.40	1.02
15	I often access online resources while preparing my lesson plans.	49 47.6%	32 31.1%	13 12.6%	9 8.7%	3.17	0.96
16	I often get new pedagogical ideas from related websites.	27 26.2%	44 42.7%	22 21.4%	10 9.7%	2.85	0.92
17	I have limited access to digital technologies for science teaching	28 27.2%	27 26.2%	37 35.9%	11 10.7%	2.70	0.99
18	I connect with other science teachers through social media platforms	26 25.2%	33 32%	30 29.1%	14 13.6%	2.69	1.00
19	I often give my students an assignment that involves internet browsing	31 30.1%	38 36.9%	24 23.3%	10 9.7%	2.87	0.96
20	As a STEM teacher, I often use virtual laboratories for science experiments	19 18.4%	27 26.2%	35 34%	22 21.4%	2.42	1.02
21	I use a Learning Management System for teaching and computation of students' performances.	23 22.3%	29 28.2%	34 33%	17 16.5%	2.56	1.02
Weighted Mean = 2.67							
Criterion Mean = 2.5							

Table 1 reveals the responses of the respondents to science teachers' utilization of digitalization. It reveals the weighted mean of 2.67 out of the 4.00 maximum obtainable score,

which is higher than the standard mean of 2.50. This indicates that teachers to some extent utilize digital tools in teaching. Table 1 also reveals the items that contribute to the utilization of digitalization in teaching and learning science by mean scores. The 21 items are rated as follows; I am very familiar with educational software such as MATLAB, PHeT simulations, etc. (2.64>2.50), I often include online resources in my lessons (2.8>2.50), Digital tools are not available in the school I teach (2.59>2.50), I have used interactive whiteboards for my teaching (2.62>2.50), I have digital textbooks in my device for teaching science concepts (2.75>2.50), I have a computer (laptop, desktop, tablet) (3.01>2.50), I think that smart phones and other digital tools are too expensive (2.75>2.50), I have access to the internet (3.19>2.50), I often access online resources while preparing my lesson plans (3.17>2.50), I often get new pedagogical ideas from related websites (2.85>2.50), I have limited access to digital technologies for science teaching (2.70>2.50), I connect with other science teachers through social media platforms (2.69>2.50), I often give my students assignment that involves internet browsing (2.87>2.50), I use a Learning Management System for teaching and computation of students' performances (2.56>2.50).

Research Question 2: What are the primary challenges preventing STEM teachers from effectively integrating digital tools in their class?

Table 2: STEM Teachers' Challenges in Using Digitalization

S/N		SA	A	D	SD	Mean	Std.
1	I find it too tedious to integrate suitable digital resources into my science teaching	15 14.6%	37 35.9%	41 39.8%	10 9.7%	2.55	0.86
2	I have limited technical support to use digital tools	24 23.3%	46 44.7%	27 26.2%	6 5.8%	2.85	0.84
3	I would require sufficient training to use digital tools in my science classroom	31 30.1%	45 43.7%	25 24.3%	2 1.9%	3.02	0.79
4	I am unable to use any digital tool due to erratic power supply, at home and school	22 21.4%	43 41.7%	26 25.2%	12 11.7%	2.73	0.93
5	My students appear uninterested when I use digital resources in teaching	8 7.8%	19 18.4	50 48.5	26 25.2%	2.09	0.86
6	I need professional development to integrate digital technology into teaching	31 30.1%	49 47.6%	18 17.5%	5 4.9%	3.03	0.82

7	The use of digital tools in the science class takes a lot of time	17 16.5%	37 35.9%	39 37.9%	10 9.7%	2.59	0.88
8	I can effectively integrate digital technology only when I collaborate with colleagues	28 27.2%	27 26.2%	40 38.8%	8 7.8	2.73	0.95
9	I cannot afford to use digital resources such as smartphones, computers,	19 18.4%	19 18.4%	39 37.9%	26 25.2%	2.30	1.05
10	I do not have access to the internet due to the high cost of data	17 16.5%	18 17.5%	38 36.9%	30 29.1%	2.21	1.04
11	I often experience technical difficulties when I attempt to integrate digital resources into my science class	24 23.3%	30 29.1%	35 34%	14 13.6%	2.62	0.99
12	My students do not have access to tablets and laptops for playing educational games, doing research, and doing assignments.	37 35.9%	31 30.1%	31 30.1%	4 3.9%	2.98	0.91
13	I do not use any digital technology in the classroom because it is difficult to control and adequately monitor	19 18.4%	32 31.1%	42 40.8%	10 9.7%	2.58	0.90
14	I have limited knowledge of the use of Zoom, telegram, etc for teaching and interacting with my students.	27 26.2%	32 31.1%	31 30.1%	13 12.6%	2.71	1.00
15	Lack of funding is my biggest challenge in using digital technologies	36 35%	38 36.9%	25 24.3%	4 3.9%	3.03	0.87
16	I do not use digital technology because they are not available in the school I teach.	34 33%	34 33%	30 29.1%	5 4.9%	2.94	0.91
17	I have very little administrative support for the use of digitalization.	23 22.3%	48 46.6%	24 23.3%	8 7.8%	2.84	0.86
18	The Overloaded nature of the science curriculum discourages me from using digital tools for teaching	27 26.2%	20 19.4%	35 34%	21 20.4%	2.51	1.09
Measured Mean = 2.68							
Criterion Mean = 2.50							

Table 2 reveals the responses of the respondents to science teachers' challenges in using digitalization. It reveals the weighted mean of 2.68 out of the 4.00 maximum obtainable score, which is higher than the standard mean of 2.50. This indicates that teachers experience some challenges in using digitalization for science teaching. Table 1 also reveals what items contribute to the challenges of using digitalization in teaching and learning science by mean scores.

I find it too tedious to integrate suitable digital resources in my science teaching (2.55>2.50), I have limited technical support to use digital tools (2.85>2.50), I would require sufficient training in order to use digital tools in my science classroom (3.02>2.50), I am unable to use any digital tool due to erratic power supply, at home and at school (2.73>2.50), I need professional development to integrate digital technology in teaching (3.03>2.50), The use of digital tools in the science class takes a lot of time (2.59>2.50), I can effectively integrate digital technology only when I collaborate with colleagues (2.73>2.50), I often experience technical difficulties when I attempt to integrate digital resources in my science class (2.62>2.50), My students do not have access to tablets and laptops for playing educational games, doing research and assignments (2.98>2.50), I do not use any digital technology in the classroom because it is difficult to control and adequately monitor (2.58<2.50), I have limited knowledge of the use of zoom, telegram, etc for teaching and interacting with my students (2.71>2.50), Lack of funding is my biggest challenge in using digital technologies (3.03>2.50), I do not use digital technology because they are not available in the school I teach (2.94>2.50), I have very little administrative support for the use of digitalization (2.84>2.50), The Overloaded nature of the science curriculum discourages me from using digital tools for teaching (2.51>2.50).

Testing Hypotheses

Ho1: There is no significant difference between subject area and teachers' utilization of digital tools.

Table 3: Differences between Subject Areas and Teachers' Utilization of digital tools

	Sum of Suares	Df	Mean Square	F	Sig.
Between Groups	1410.224	2	705.112	8.887	0.00
Within Groups	7933.873	100	79.339		
Total	9344.097	102			

Table 4 shows that there was a significant difference between teachers' utilization of digital tools by their subject areas ($F_{(2,100)} = 8.89$: $P<0.05$)). This means that teachers' utilization of digital tools is different by their subject areas. Hence, hypothesis 1 was rejected

Ho2: There is no significant difference between subject area and challenges faced by STEM teachers in effectively integrating digital tools in their classroom

Table 4: Differences between Subject Areas and Challenges faced by the STEM Teachers' in Effectively Integrating Digital Tools in their Classroom

	Sum of Suares	Df	Mean Square	F	Sig.
Between Groups	132.222	2	66.111	0.813	0.447
Within Groups	8136.205	100	81.362		
Total	8268.427	102			

Table 4 shows that there was no significant difference between challenges faced by the STEM teachers in effectively integrating digital tools in their classroom by their subject areas ($F_{(2,100)} = 0.81$: $P>0.05$). This means that challenges faced by STEM teachers in effectively integrating digital tools in their classroom do not differ by their subject areas. Hence, hypothesis 2 was not rejected.

4. Discussion

The study's findings reflect the teachers' views on digitalization in the science classroom. A good number of them see it as a welcomed initiative. However, science teachers in Ibadan seldom use digitalization in class. This may be attributed to the inadequacy and unavailability of digital tools in the schools. STEM teachers rarely communicate with students using social media such as WhatsApp, Facebook, and Google Classroom. Furthermore, the teachers reported that smartphones and other digital tools are too expensive. They do not often conduct assessment tests online and do not use virtual laboratories for science experiments. Based on Rogers' Diffusion of Innovations theory, teachers will be more willing to utilize digital tools in teaching because they are seen as helpful innovations, communicated through various

channels, adopted over time, and influenced by the social system of the educational environment. Perhaps, early adoption in the academic community could facilitate the diffusion of digital tools.

It was also noted that there are attendant challenges in using digitalization, including a lack of technical capacity, students' lack of access to digital tools, and funding issues. This agrees with the suggestion made by Khalid et al. (2025) and Abiodun et al. (2023) that even if there is an adequate supply of digital tools, there should be a concurrent process of capacity-building for the teachers who are the implementers. Among the biology, chemistry, and physics teachers, there seem to exist similarities in their issues with digitalization. No special funds are allotted to any particular science subject. Therefore, there are bound to be common barriers and challenges with incorporating digitalization in the science classroom.

The trends in the usage of digital tools among STEM teachers reveal a significant difference in teachers' demographics based on subject demographics based on subject area. STEM teachers often use digital tools due to the availability of specialized software for simulations, coding, and data analysis.

5. Conclusions and Recommendation

Digital technologies can be effectively utilized in science teaching and learning to foster learning. However, they are barely used by the teachers. Among the challenges faced in this area are lack of funding, technical skills, and capacity. Although Biology, Chemistry and, Physics teachers tend to use digital tools differently, their challenges are commonly shared. It can be suggested that strategic support in the form of supply of equipment, funding and technical training should be provided to schools in the Ibadan metropolis. Besides, teachers should be trained on digitalization in science pedagogy.

Acknowledgments

We acknowledge the valuable cooperation of the teachers and School Heads within the Ibadan metropolis.

Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest.

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