

Original Article

INTEGRATING DIGITAL TECHNOLOGIES IN TRANSFORMING SECONDARY SCHOOL SCIENCE TEACHING: SCIENCE TEACHERS' PERSPECTIVE IN OGUN STATE, NIGERIA

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Abstract

Digital technologies applications for the purpose of knowledge delivery have been generally acknowledged as a pathway towards a scientific literacy and technology-driven world. The study investigated the integration of digital technologies in transforming secondary school science teaching and learning with a focus on science teachers' perspective. The cross-sectional descriptive survey research design was adopted for the study. Using a purposive sampling technique, 168 science teachers in both public and private secondary schools in Ijebu-Ode, Ogun state were selected for the study. The instrument for data collection was *Questionnaire on Digital Technologies in Transformation Science Teaching* with reliability index of $r = 0.89$. Data obtained for the study were analyzed using descriptive statistics of frequency count, horizontal bar chart, percentage, mean, and standard deviation. The findings of the study indicated that a generally low extent of digital technology utilization by science teachers, science teachers rarely use digital tools in their instructional practices [Mean = 2.16, Stdv = 0.96], science teachers exhibit a low level of proficiency in developing digital science resources through the use of digital technologies [Mean = 2.08, Stdv = 0.93] and science teachers positively agreed with the strategies identified for bridging gaps in digital technology proficiency [Mean = 3.39, Stdv = 0.95]. The study recommends that Government and school authorities should prioritize the supply of modern hardware and software digital technologies to enhance quality science teaching in secondary schools. Regular professional development programs, including workshops, seminars, and online courses, should be organized to enhance science teachers' proficiency in creating and utilizing digital science resources. Policymakers should institutionalize mentorship, peer-learning programs, and ICT resource centers as part of a structured approach to strengthen teachers' digital competencies among others.

Keywords: Digital Technologies, Integration, Science Teachers, Science Teaching, Transformation.

Introduction

Science teaching and learning as consistently been acknowledged as a fundamental element of human advancement as it laid the foundation to all technological breakthroughs. The effects of science has a field of study is prodigious, unavoidable and

undoubtedly a vehicle for transformation. Scientific knowledge is a product of an equilibrium process of cause and effect relationship that provide distinctive premise to the elimination of myth and superstitious notions. Undoubtedly, science has significantly provided solutions to diverse challenges encountered

by humans. However, it is pertinent to note that the traditional pedagogical approach of teaching and learning science, though historically prevalent and still commonly employed in the developing countries, is increasingly seen as inadequate for equipping students to tackle contemporary scientific and technological issues (McPherson & Pearce, 2022).

Aderonmu and Agbesor (2025) explained that the traditional pedagogical approach to science teaching and learning is lopsided because more emphases is placed on the teacher who act as the embodiment and sole transmitter of knowledge while the learners are characterized as passive audience. It is text-book based with high emphasis on rote memorization with little or no students' participation in the intellectual process as it is strictly limited to space and time. In contrast to the traditional approach to the teaching and learning of science, there is need for the 21st century knowledge dynamics which requires flexible, learner-centred, scientific reasoning, creativity, active engagement and digital literacy and skills that must be acquired by teachers and learners which accentuate the necessity for the transformation of science teaching and learning. Transforming science teaching and learning in the 21st century involves redefining the way scientific knowledge is disseminated, engaged, comprehended and employed by today's learners. Transformative science teaching and learning aims to involve students in significant scientific investigation, analytical reasoning, and problem solving mentality. It transcends educational phase of memorization to cultivating profound conceptual understanding with hands-on abilities, and the capacity to utilize scientific knowledge in real world contexts (Kibga, Sentongo & Gakuba, 2021).

Contemporary science teaching and learning must foster the 21st century skills of critical thinking, creativity, collaboration, and problem-solving skills. Nyongesa and Westhuizen (2025) reiterated that transforming science teaching and learning in the

21st century can only be driven by the advancements in digital technology which proposes a shift towards student-centered pedagogies, and the need to align learning with real-world scientific challenges having concrete solutions. That is to say, the acquisition of scientific knowledge in today's technological driven digital world has demystified the limits of space and time whereby the process of science teaching and learning can be online, remote and virtual. Therefore, integration of digital technologies into science teaching and learning cannot be luxury but has become imperative in this era of knowledge driven space and compulsory in the attainment of scientific and technological advancement in a digital world. A digital world is a space where technology is ubiquitous, essential for our communication, influences our lifestyles, work conducts and provides spontaneous access to knowledge on the internet through digital devices. The integration of digital technologies in education has revolutionized the teaching and learning landscape across the globe as Diana and Sari (2024) opined that the presence of digital technologies has not only distorted the entire ecosystem of science pedagogy but has created new pathway for inclusive learning, flexibility, personalized and collaborative synergies in the intellectual space. Selwyn (2020) defined digital technologies as those tools that facilitate both communication and computation in support of teaching and learning, provide administrative platforms within the contexts of educational environments, Learning Management Systems, Online collaboration and AI-driven tutors. Ng (2022) wrote that;

“Digital technologies utilized in education encompass a variety of tools that includes virtual learning environments, digital assessment platforms, educational applications, and collaborative online resources—that improve instructional delivery, foster learner engagement, and facilitate personalized learning pathways”

Hussai, Qureshi, and Malik (2024) emphasized that digital technologies have the power to democratize access to scientific knowledge, personalize instruction, deepen student engagement, and prepare learners for the digital and scientific demands of the modern world. The integration of digital technologies in science teaching and learning according to United Nations Children's Fund (2020) stipulated that the leverage can mitigate any barrier to understanding science even in cases of disruptive emergencies. Digital technologies integration in science teaching and learning holds promise for enhancing learning outcomes as it offers numerous benefits such as increased accessibility, engagement, and personalized learning. Ibrahim and Jibia (2024) and Mdpi, et al. (2024) commented that interactive simulations, virtual labs, and multimedia resources can make complex science concepts more understandable and engaging. Digital technologies also facilitate collaborative learning, promote students interaction and foster a more inclusive learning environment. UNESCO (2023) opined that digital technologies can bridge educational gaps by providing resources to underserved communities and

enhancing the overall educational experience. The fundamental requirement in the process of integrating digital technologies for the purpose of effective science teaching and learning is the acquisition of digital literacy.

Nwabuwe (2024) denotes that digital literacy is the ability to efficiently access, generate and convey information through digital technologies. Moses (2023) opined that in order to effectively create, utilize and manage technological processes and resources aimed at providing enriched instructional processes for optimal learners' performance, one requires digital literacy. However, the idea of digital literacy goes beyond the acquisition of technical abilities but must incorporate critical thinking, ethical utilization of digital content, communication and the skill to maneuver through various digital landscapes. Within the educational framework, digital literacy encompasses not just the operation of devices and software, but also the thoughtful application of these tools to address challenges, work collaboratively with others in pursuit to the production of knowledge.



Figure 1: Digital literacy skills for science teachers.

Digital literacy skills are essential for science educators as they navigate a swiftly changing educational environment. These interconnected skills

promote deeper inquiry, innovation, and inclusivity in the teaching and learning of science.

- i. Technical skills allow teachers to effectively utilize digital devices, scientific software, and learning management systems to improve instructional delivery (Teane, 2024).
- ii. Information literacy is vital for recognizing credible scientific information, assessing online resources, and guiding students in research methodologies that maintain academic integrity (Ireru & Ocholla, 2025).
- iii. Communication skills facilitate the use of digital tools for collaboration, feedback, and virtual interactions, thereby enhancing student engagement and participation (Trust & Whalen, 2020).
- iv. Digital content creation skill empowers educators to design interactive simulations, videos, and digital laboratories that encourage active learning in science (Lee & Kim, 2024)
- v. Critical thinking is crucial for assessing scientific assertions and digital resources, prompting students to analyze data and develop evidence-based conclusions (Ani et al., 2020).
- vi. Data literacy enables teachers to effectively interpret and utilize educational and scientific data, which improves assessment practices and supports data-driven instruction (Ologbosere, 2023).

The significance of digital literacy has grown exponentially as instructional methods transit towards inquiry-based, digital enhanced and student-centered. In science teaching and learning, digital literacy facilitates a more profound engagement with scientific material by providing access to multimedia resources, scientific databases, and online collaboration tools. At this point, learners are able to visualize complex phenomena, perform experiments virtually and engage in a global scientific discussion and crave more enthusiasm for science (Aderonmu & Obafemi, 2022). It is imperative that science teachers not only receive training in the use of digital tools but also in mentoring students on the responsible, critical, and innovative application of these technologies for scientific exploration. As digital technologies increasingly serve as the

primary medium for the dissemination of content knowledge, the responsibilities of science teachers utilizing these digital tools become more intricate, as their level of digital proficiency significantly impacts the quality and effectiveness of science teaching and learning. In the context of this study, proficiency level refers to the ability of science teachers to select, employ, and integrate digital tools effectively to enhance scientific understanding and inquiry. Ogegbo (2023) noted that the digital proficiency level relevant to science teachers is a combination of their confidence and competence in using digital technologies for the purpose of science instruction. The extent of their proficiency level will project how they will employ these digital technologies for the purpose of simulations, virtual laboratories, data analysis among others aimed at deepening students' comprehension of intricate scientific principles. These resources promote active learning and cultivate advanced cognitive skills, such as hypothesis development, experimentation, and data analysis.

Ostensibly, in the Sub-Saharan Africa especially Nigeria where there seems to be diverse educational challenges due to inadequate infrastructure and resource gaps, there is need for availability and utilization of digital technologies as it presents unprecedented opportunities for transforming science pedagogy (Nyongesa & Westhuizen, 2025). The availability and utilization of digital technologies signifies the degree to which schools and educational institutions possess the technological resources and infrastructure required for digital education and their actual use in instructional practices. Globally, UNESCO (2021) stipulated that there have been remarkable increase in availability and utilization of digital technologies as classified as hardware and software digital technologies.

- (i) Software digital technologies are applications created to accomplish digital task and special functions such as communication, simulation,

interactivity, data analysis, virtual labs, creation and modification of virtual contents among others. Adeoye and Oyeleye (2024) described software digital technologies as tools that serve as educational instruments and platforms which functions via digital interfaces to provide content, enable simulations, improve interaction, and assist in assessment within virtual or hybrid learning environments. These technologies enable users to create, access, manipulate, and share digital content efficiently. In the teaching and learning of science, these software tools offer significant influence by credible participatory engagement, access to multimedia educational content, feedback and

assessment mechanism and virtual learning environment (UNESCO, 2023).

(ii) Digital hardware technologies are physical ICT instruments that provide the essential framework for the deployment of educational software, the distribution of content, and the facilitation of interactive science instruction. Without hardware, most software digital technologies cannot function as they provide the interface through which users interact with digital content and applications (Hidayat-ur-Rehman, 2020). When educators have access to appropriate hardware, they can engage students more effectively, particularly in STEM disciplines where visualization and interaction are crucial.

Hardware Digital Technologies	Software Digital Technologies
• Desktop Computers • Laptop Computers • Tablets • Smartphones • Interactive Whiteboards • Projectors • Scanners • Printers • Digital Cameras • Network Routers and Switches • Servers • VR Headsets • Robotics Kits • Microcontrollers (e.g. Arduino, Raspberry Pi)	• Operating Systems (e.g. Windows, macOS, Android) • Word Processing Software (e.g. Microsoft Word, Google Docs) • Spreadsheet Tools (e.g. Microsoft Excel, Google Sheets) • Learning Management Systems (e.g. Moodle, Google Classroom, Canvas) • Web Browsers (e.g. Chrome, Firefox, Safari) • Educational Apps (e.g. Kahoot!, Duolingo) • Programming Software (e.g. Python, Scratch, Visual Studio Code) • Graphic Design Software (e.g. Adobe Photoshop, CorelDRAW) • Simulation Software (e.g. PhET Interactive Simulations, Labster)

Figure 2: Hardware and Software Digital Technologies for science teachers.

The combination of software and hardware digital technologies is fundamental for the creation of digital science online resources. As stated by Clark-Wilson et al. (2020), infusing these resources into science classrooms enhances student engagement, fosters critical thinking, and aids in the cultivation of

scientific literacy. In light of the increasing prevalence of blended learning especially in science teaching and learning, these tools have become essential for rendering science education more flexible and inclusive. Digital science online resources facilitate differentiated instruction by

accommodating diverse learning styles and enabling students to progress at their own pace. Online tutorials, animations, and quizzes allow students to review content as necessary, thus enhancing their mastery.

The drive for transformation extends beyond mere modernization; it encompasses the need for relevance while preparing students with the necessary skills to participate in a digitized scientific environment. Digital technologies facilitate dynamic and interactive experiences that surpass traditional textbooks, promoting a more profound conceptual understanding. One of the most significant advancements brought about by digital technologies in the science teaching and learning is the capacity to visualize abstract concepts through the use of simulations, animations, and virtual laboratories. These resources render invisible or intricate scientific processes both accessible and understandable, which are especially beneficial in disciplines such as physics, chemistry, and biology (Fabeku, & Enyeasi, 2024). For example, simulations can replicate molecular behavior, enabling students to engage with scientific phenomena within a controlled virtual setting. These visual aids not only enhance comprehension but also bolster students' retention and application of scientific principles. When digital technologies tools are employed strategically to enhance inquiry, collaboration, and critical thinking, they serve as catalysts for genuine and enduring educational transformation in the teaching and learning of science.

Digital technologies present significant opportunities to revolutionize science teaching and learning by promoting interactive, personalized, and inquiry-driven learning. Nevertheless, the integration of these tools in science instructional practices is accompanied by various challenges. These challenges encompass infrastructural inadequacies, restricted teacher capabilities, gaps in policy, and resistance to changes in pedagogy. The digital

competence of science teachers is essential for the effective integration of digital technologies. Numerous science teachers may not possess the requisite skills and confidence to meaningfully incorporate digital tools into their teaching practices (Tondeur et al., 2018). Additionally, there may be frequent resistance to change stemming from established (traditional) teaching habits, insufficient training, or doubts regarding the educational benefits of integrating digital technology. Opportunities for professional development are often narrow in focus, lacking the sustained, practical support necessary to promote the long-term adoption of digital strategies. This study is significant because it addresses the urgent need and tackles the pressing necessity to modify science teaching and learning in order to fulfill the requirements of the digital landscape of the 21st century. With science becoming progressively reliant on digital technologies, it is crucial to provide students with the pertinent digital skills and competencies to adequately prepare them for forthcoming academic and professional prospects which is dependent on the availability of digital technologies and level of science teachers' proficiencies of digital literacy and skills. In light of the above, the study seeks to explore the integration of digital technologies in transforming secondary school science teaching and learning with a focus on science teachers' perspective in Ogun State, Nigeria.

Purpose of the Study

The aim of the study is to investigate the integration of digital technologies in transforming secondary school science teaching and learning with a focus on science teachers' perspective. Specifically, the objectives of the study are to;

- (i) Investigate the availability of digital technologies (Hardware and Software) for science teaching in secondary schools.
- (ii) Ascertain the extent science teachers utilize digital technologies for science teaching in secondary schools?

(iii) Determine the proficiency level of secondary school science teachers in creating digital science resources using digital technologies for science teaching.

(iv) Examine the strategies employed to bridge the gaps in digital technology proficiency levels among secondary school science teachers for science teaching in secondary schools.

Research Questions

The following research questions will guide the study.

1. Are there available digital technologies (Hardware and Software) for science teaching in secondary schools?
2. To what extent do science teachers utilize digital technologies for science teaching in secondary schools?
3. What is the proficiency level of secondary school science teachers in creating digital science resources using digital technologies for science teaching?
4. What are the strategies employed to bridge the gaps in digital technology proficiency levels among secondary school science teachers for science teaching in secondary schools?

Methodology

The study adopted the cross sectional descriptive survey research design. The cross-sectional

Table 1.

Showing participants categorized in terms of gender

Gender	Frequency	Percentage
Male	98	59.7%
Female	70	40.3%

Source: Researchers' fieldwork, 2025.

The gender composition of the respondents reveals that out of 168 participants, 98 (59.7%) were male, while 70 (40.3%) were female. This indicates a slightly higher participation of male respondents in the study.

descriptive survey research design represents a quantitative approach where data is gathered from a specified population at one specific moment to outline current characteristics, attitudes, behaviors, or conditions. This method does not entail the manipulation of variables or the establishment of causality (Capili, 2022). The study was conducted in Ijebu-Ode Local Government Area of Ogun State, Nigeria. The approximate geographical coordinates of Ijebu-Ode, located in Ogun State, Nigeria are (Latitude: 6.8194° N, Longitude: 3.9173° E). Ijebu-Ode is well-known for its profound emphasis on education. This town has consistently valued formal education highly, as evidenced by the numerous reputable primary, secondary, and tertiary institutions present.

The population of the study comprised all secondary school science teachers teaching in Ijebu-Ode Local Government Area of Ogun State. Using a purposive sampling technique, 168 secondary school science teachers were selected as participants for the study with basic criteria that they have engaged in Tech training sponsored by government, private sector, NGO or self-sponsored. Below provides the demographic distribution of the 168 participants involved in the study, categorized by gender, school type, and teaching experience.

Table 2.

Showing participants categorized in terms of school type.

School Type	Frequency	Percentage
Public	60	35.7%
Private	108	64.3%

Source: Researchers' fieldwork, 2025.

In terms of school affiliation, 60 respondents (35.7%) were from private schools, whereas 108 respondents (64.3%) were from public schools. This

shows that a majority of the participants teach in private school settings.

Table 3.

Showing participants categorized in terms of years of experience.

Experience	Frequency	Percentage
< 5 years	61	36.3%
5–10 years	83	49.4%
11 years and above	24	14.3%

Source: Researchers' fieldwork, 2025.

The distribution of teaching experience among the respondents is as follows: 61 teachers (36.3%) have less than five years of experience, 83 teachers (49.4%) have between five to ten years of experience, and 8 teachers (14.3%) have more than eleven years of experience. This indicates that a majority of the respondents are in the early to mid-stages of their teaching careers.

A self-researchers' designed questionnaire titled "Questionnaire on Digital Technologies in Transformation Science Teaching" (QD TTST) with five sections was employed for the study. Section A was designed to obtain demographic information of the respondents used for the study while section B represents a checklist of both software and hardware digital technologies to inquire whether they are available for science teaching in secondary schools or not. The item statements stipulated in Section C provide a template for addressing the extent science teachers utilize digital technologies for science teaching in secondary schools. Section D was designed and aimed at ascertaining the proficiency level [Never = 1, Beginner = 2, Intermediate = 3, Advanced = 4 and Expert = 5] of secondary school

science teachers in creating digital science resources using digital technologies for science teaching. In other to determine strategies to bridge the gaps in digital technology proficiency levels among secondary school science teachers for science teaching in secondary schools, the item statements of Section E was used to address this problem.

Questionnaire on Digital Technologies in Transformation Science Teaching (QD TTST) was validated by experts in Education and Media Technology, Science Education and Measurement and Evaluation. QD TTST was administered by the researchers and four trained research assistance. Pilot studies was conducted by subjecting the instrument QD TTST to 20 science teachers in same location but were not involved in the study. Data collected was used to determine the reliability of the instrument by employing the Cronbach Alfa reliability formula. A reliability index value of 0.84 was obtained making the instrument 84% reliable for the study. Data collected for the main study was analyzed using frequency count, horizontal bar chart, percentage, mean and standard deviation.

Results

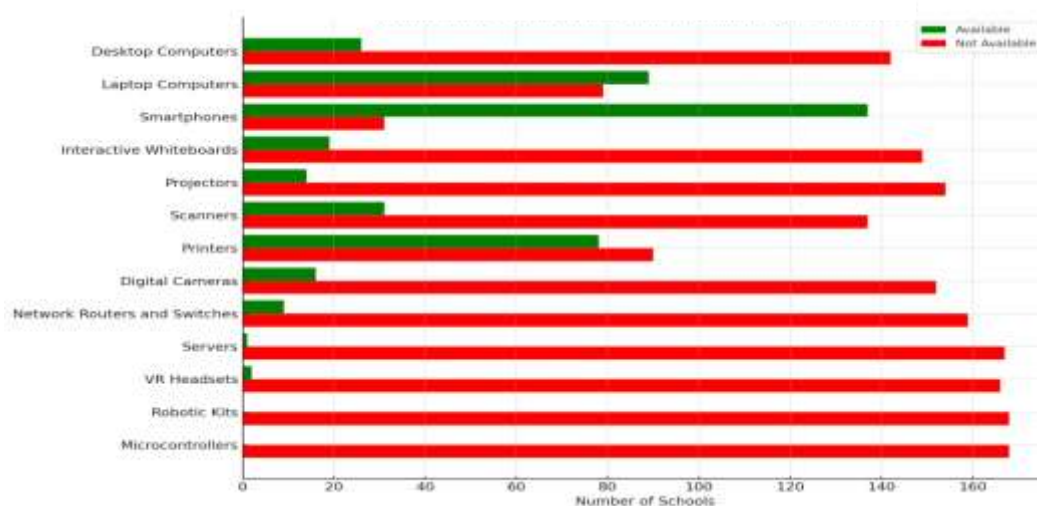
Research Question 1: Are there available of digital technologies (Hardware and Software) for science teaching in secondary schools?

Table 4.

Showing science teachers response on availability of hardware digital technologies

Hardware Digital Technologies	Available	Not Available
Desktop Computers	26 (15.5%)	142 (84.5%)
Laptop Computers	89 (53.0%)	79 (47.0%)
Samrtphones	137 (81.5%)	31 (18.5%)
Interactive Whiteboards	19 (11.3%)	149 (88.7%)
Projectors	14(8.3%)	154 (91.7%)
Scanners	31 (18.5%)	137 (81.5%)
Printers	78 (46.4%)	90 (53.6%)
Digital Cameras	16(9.5%)	152 (90.5%)
Network Routers and Switches	9 (5.4%)	159 (94.6%)
Servers	1 (0.6%)	167 (99.4%)
VR Headsets	2 (1.2%)	166 (98.8%)
Robotic Kits	0 (0.0%)	168 (100,0%)
Microcontrollers	0 (0.0%)	168 (0.0%)

Source: Researchers' fieldwork, 2025.



Source: Researchers' fieldwork, 2025.

The chart reveals significant disparities in the availability of digital hardware across schools. It was shown that smartphones (81.5%) and laptop computers (53.0%) are the most available technologies. This reflects the growing penetration of mobile and portable devices in educational

contexts. Printers (46.4%) and scanners (18.5%) also show some presence, indicating a moderate level of access to document-related tools. The limited access to interactive tools like whiteboards (11.3%) and projectors (8.3%) hampers the potential for multimedia-enhanced instruction. Robotic Kits (0%),

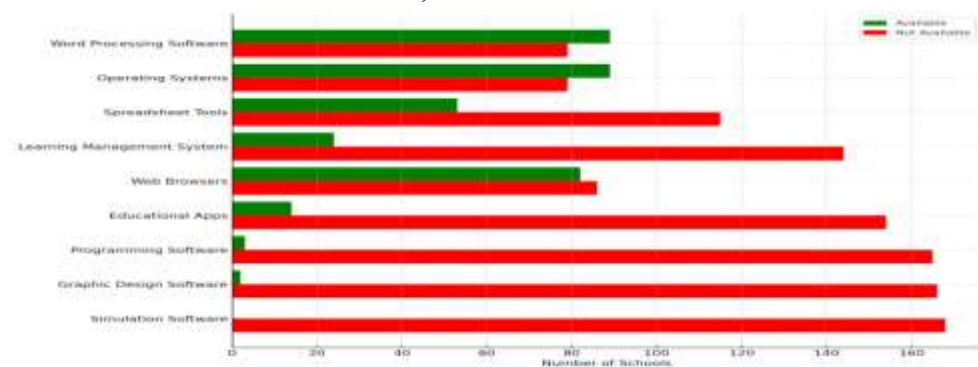
Microcontrollers (0%), and Servers (0.6%) are virtually absent. These tools are crucial for advanced STEM education and indicate a lack of support for hands-on, emerging technology learning. Network routers/switches (5.4%), VR headsets (1.2%), and digital cameras (9.5%) also show critically low

Table 5.

Showing science teachers response on availability of software digital technologies

Software Digital Technologies	Available	Not Available
Word Processing Software	89 (53.0%)	79 (47.0%)
Operating Systems	89 (53.0%)	79 (47.0%)
Spreadsheet Tools	53 (31.6%)	115 (68.4%)
Learning Management System	24 (14.3%)	144 (85.7%)
Web Browsers	82 (48.8%)	86 (51.2%)
Educational Apps	14 (8.3%)	154 (91.7%)
Programming Software	3 (1.8%)	165 (98.2%)
Graphic Design Software	2 (1.2%)	166 (98.8%)
Simulation Software	0 (0.0%)	168 (100.0%)

Source: Researchers' fieldwork, 2025.



Source: Researchers' fieldwork, 2025.

The data clearly indicates a widespread lack of essential educational software in schools. While basic tools like word processors and operating systems show moderate availability, more specialized and educationally transformative software type such as simulation, programming, and graphic design tools are severely lacking. Word Processing Software (53.0%) and Operating Systems (53.0%) are the most commonly available tools, found in over half of the schools. This suggests that schools prioritize basic productivity and functionality. Web Browsers (48.8%) also show

availability, highlighting infrastructural gaps in multimedia and immersive learning. The findings of the study generally indicated that there is limited availability of hardware digital tools used by science teachers for science teaching.

moderate availability, likely reflecting the use of internet-based learning and browsing capabilities. Simulation Software (0%) is completely unavailable, indicating that schools do not utilize interactive models for science or technical subjects which are critical for understanding complex concepts. Graphic Design Software (1.2%), Programming Software (1.8%), and Educational Apps (8.3%) are almost entirely absent. This reflects a digital skills gap, particularly in areas aligned with creative thinking, software development, and interactive learning. The findings of the study also indicated that there is

limited availability of software digital tools used by science teachers for science teaching.

Research Question 2: To what extent do science teachers utilize digital technologies for science teaching in secondary schools?

Table 6.

Showing the extent of science teachers' utilization of digital technologies for science teaching.

S/N	ITEM STATEMENTS	VHE	HE	LE	VLE	Mean	Std
1	I use digital projectors or interactive whiteboards to deliver science lessons	11	17	81	59	1.88	0.84
2	I integrate multimedia resources to explain scientific concepts.	9	14	84	61	1.83	0.79
3	I employ learning management systems for teaching science topics.	16	21	74	57	1.98	0.92
4	I use educational science apps and simulations during classroom instruction.	13	28	89	38	2.10	0.83
5	I incorporate online assessments or quizzes to evaluate students' understanding of science topics.	19	39	61	49	2.17	0.97
6	I use internet resources to supplement science instruction.	41	37	27	63	2.33	1.21
7	I prepare and deliver science lessons using presentation software	14	15	66	73	1.82	0.91
8	I utilize virtual labs or science simulations in teaching practical science skills.	20	13	78	57	1.98	0.94
9	I communicate with students via digital platforms for science related discussions.	56	54	16	42	2.74	1.01
10	I assign or recommend science related digital resources for students' independent study.	38	61	47	22	2.68	0.96
11	I use spreadsheet tools to record and analyze students' performance in science.	21	33	40	78	2.03	1.08
12	I guide students on how to use digital tools for conducting science research or projects	13	18	63	94	1.94	0.97
13	I access and adapt digital lesson plans or science teaching materials from online sources.	41	71	27	29	2.74	1.01
14	I incorporate virtual or augmented reality tools to enhance science lessons.	9	14	73	72	1.76	0.82
15	I participate in online professional development programs to improve my digital teaching practices in science	24	21	32	91	1.87	1.10
Overall general Mean and						2.16	0.96
Stdv							

Source: Researchers' fieldwork, 2025.

The analysis of Table 6 revealed that the overall general mean of 2.16 with a standard deviation of 0.96 indicates a generally low extent of digital technology utilization by science teachers in the sampled context. This finding suggests that most teachers rarely use advanced digital tools in their instructional practices, as the mean values of most items fall below the mid-point (2.50) of the 4-point

Likert scale. Items such as the use of digital projectors (M = 1.88), multimedia resources (M = 1.83), and guiding students in digital research (M = 1.94) show particularly low utilization, reflecting the limited integration of digital technologies in teaching. Interestingly, a few items such as communicating with students via digital platforms (M = 2.74, SD = 1.01) and accessing/adapting online

lesson plans ($M = 2.74$, $SD = 1.01$) recorded higher mean values compared to others. This suggests that teachers are more comfortable using readily available and less resource-intensive digital practices rather than advanced technologies like virtual labs ($M = 1.98$) or virtual/augmented reality ($M = 1.76$). The findings of the study revealed that the extent of

Table 7.

Showing the proficiency level science teachers' teachers in creating digital science resources using digital technologies.

S/N	Digital Skills for Creating Digital Online Science Resources	Mean	Stdv
1	Presentation tools (PowerPoint/Google Slides)	2.41	0.93
2	Video Editing	2.03	1.03
3	Audio Editing	1.97	0.84
4	Animation/Graphic	1.82	0.91
5	Web Development (CSS/JavaScript)	1.67	0.80
6	LMS (Google Classroom, Canvas, Moodle)	2.18	1.10
7	Data Visualization (Excel charts)	2.30	0.95
8	Accessibility tools (Captions, Alt text)	1.98	1.02
9	Speech-to-text tools	2.22	0.90
10	Collaboration tools (Google Docs, Slack, Teams)	2.35	0.92
11	Simulations/Virtual Labs (PhET, Labster)	1.86	0.87
12	E-learning tools (Storyline, Captivate)	1.94	0.86
13	Screen recording and Screencasting	2.27	1.02
Overall general Mean and Stdv		2.08	0.93

Source: Researchers' fieldwork, 2025.

Based on the result presented in the Table 7, the overall mean of 2.08, accompanied by a standard deviation of 0.93, suggests that secondary school science teachers exhibit a low level of proficiency in developing digital science resources through the use of digital technologies. In comparison to the criterion mean of 3.00 (Intermediate level), it is clear that teachers do not meet the anticipated competency standard in most digital skills. The relatively high standard deviation indicates a range of abilities

science teachers' utilization of digital technologies for science teaching in secondary schools is very low.

Research Question 3: What is the proficiency level of secondary school science teachers in creating digital science resources using digital technologies for science teaching?

among teachers, with some demonstrating slightly greater proficiency in fundamental tools such as presentation software, collaboration tools, and data visualization, while others remain at a novice level, especially in more advanced skills like web development, e-learning authoring, and simulations.

Research Question 4: What are the strategies employed to bridge the gaps in digital technology proficiency levels among secondary school science teachers for science teaching in secondary schools?

Table 8.

Showing science teachers' response on strategies employed to bridge the gaps in digital technology proficiency levels

S/N	ITEM STATEMENTS	Mean	Std
1	Regular in-service training and workshops help me improve my digital skills for science teaching.	3.45	0.81
2	Mentorship and peer-learning programs with colleagues enhance my proficiency in digital technologies.	3.38	1.04
3	Access to modern digital tools and software enables me to create effective science teaching resources.	3.42	0.96
4	Teacher professional development programs should include digital pedagogy courses for science teaching.	3.51	0.99
5	ICT resource centers in schools are essential for improving teachers' hands-on digital proficiency.	3.48	1.01
6	Collaborative projects with colleagues help me gain confidence in using digital tools for teaching science.	3.32	0.88
7	Online self-paced training modules are effective in strengthening teachers' digital skills.	3.28	0.91
8	Incentives and recognition motivate teachers to integrate digital resources into science teaching.	3.36	0.93
9	Reliable internet connectivity and technical support are necessary to improve teachers' digital competencies.	3.55	1.00
10	Partnerships with edtech companies and universities enhance teachers' exposure to emerging digital tools.	3.40	0.95
11	Embedding digital literacy and resource creation in teacher appraisal systems encourages skill development.	3.30	0.87
12	Professional learning communities (PLCs) are effective in sharing knowledge about digital science innovations.	3.34	0.91
13	Open educational resources (OERs) and free digital tools help teachers overcome barriers to resource creation.	3.44	1.04
14	Participation in webinars, MOOCs, and online courses improves teachers' proficiency in digital science teaching.	3.37	1.02
15	Continuous monitoring and evaluation help track teachers' progress in using digital tools for science teaching	3.29	0.92
Overall general Mean and Stdv		3.39	0.95

Source: Researchers' fieldwork, 2025.

The results in the Table 8 revealed an overall general mean of 3.39 with a standard deviation of 0.95, indicating that secondary school science teachers positively agreed with the strategies identified for bridging gaps in digital technology proficiency. Since the overall mean is well above the criterion mean of 2.50, it suggests that respondents strongly believe strategies such as in-service training, mentorship, ICT resource centers, reliable internet,

and professional development programmes are effective in enhancing their digital skills for science teaching.

Discussion of Findings

The study was concerned in investigating the integration of digital technologies in transforming secondary school science teaching and learning with a focus on science teachers' perspective in Ogun State, Nigeria. The findings of this study if research

question one revealed that there is limited availability of both hardware and software digital tools used by science teachers for classroom instruction. This outcome aligns with earlier studies that documented persistent inequalities in access to digital resources, particularly in low and middle income countries (Dogo et al. (2021); Eggon, Allu & Ameh (2024). While some schools may have basic infrastructure such as projectors or computers, advanced science-specific tools such as virtual labs, simulation software, and e-learning platforms remain scarce. The lack of adequate hardware, including interactive whiteboards, tablets, and reliable internet connectivity, further compounds teachers' ability to implement innovative, technology-supported pedagogy in science education (Gudmundsdottir & Hatlevik, 2021). The absence of sufficient hardware and software also limits the scope of digital pedagogy, reducing science teaching to mostly presentation tools rather than interactive and inquiry-based approaches. Research has shown that access to functional digital devices and specialized software is strongly correlated with teachers' adoption of student-centered teaching methods that foster critical thinking and problem-solving (Adeoye & Oyeleye, 2024). In contrast, where availability is restricted, teachers often resort to traditional methods or underutilize technology in ways that do not significantly transform learning. This finding resonates with studies in sub-Saharan Africa and Asia that emphasized how inadequate access to resources remains a major barrier to meaningful technology integration in science classrooms (Adebisi et al., 2021; Ifinedo & Usoro, 2024). Moreover, the findings underscore the importance of systemic interventions that go beyond providing minimal access to digital resources. Scholars argued that improving digital integration in science education requires consistent investment in both hardware and software, coupled with policies that ensure equitable distribution across schools (Bulman & Fairlie, 2016; OECD, 2023).

The results of this research revealed a generally low level of digital technology use among science teachers in secondary schools. This finding is consistent with earlier studies that showed the discrepancies despite the growing availability of ICT in educational settings, science teachers still underutilize digital resources for teaching purposes (Jack & Ayuba, 2022; Ibrahimi, & Ismail, 2023). A significant number of science teachers continue to rely on conventional teaching methods, with digital technologies mainly employed for fundamental tasks such as presentations, rather than for interactive or inquiry-based science teaching and learning.

Research has shown that digital technologies, including simulations, virtual laboratories, and data visualization tools, can significantly improve conceptual understanding, foster critical thinking, and render abstract scientific concepts more accessible (Gudmundsdottir & Hatlevik, 2021). Nevertheless, when these tools are not properly integrated into science classrooms, students miss out on valuable learning experiences. Similar observations during the COVID-19 pandemic demonstrated that numerous science teachers struggled to adapt to online teaching due to insufficient digital pedagogical skills, resulting in diminished engagement and learning effectiveness (Adedoyin & Soykan, 2020).

The findings of this study (research question three) indicated that secondary school science teachers exhibit a low level of proficiency in developing digital science resources through the use of digital technologies. This aligns with previous research showing that while many teachers are aware of digital tools, their ability to effectively design and create subject-specific digital resources remains limited (Gür et al., 2024). In particular, teachers often struggle with advanced skills such as video editing, animation, simulation design, and e-learning content creation, which are crucial for enriching science instruction (Nguyen et al., 2023). The low proficiency levels reported in this study reflect a

broader digital skills gap in the teaching workforce, especially in resource-constrained educational systems (Oladipo & Bello, 2022).

This limited proficiency restricts the integration of innovative, interactive, and student-centered pedagogies in science teaching. Rather than creating engaging resources such as simulations, virtual labs, or interactive presentations, many teachers rely on basic tools like PowerPoint or textbook-based instruction (Gür et al., 2024). Studies have shown that when teachers lack the skills to design digital learning materials, students miss out on opportunities to engage in inquiry-based and experiential science learning (Gudmundsdottir & Hatlevik, 2021). Similar to the present findings, research during the COVID-19 pandemic highlighted that many teachers worldwide were unprepared to design digital learning content, which limited the effectiveness of online science teaching (Adedoyin & Soykan, 2020).

The findings also highlight the urgent need for capacity-building initiatives to strengthen teachers' digital content development skills. Scholars argue that professional development programs should move beyond basic ICT literacy and focus on pedagogical content creation using digital technologies (Trust et al., 2022; Ifinedo & Usoro, 2024). For instance, training on authoring tools, virtual laboratories, and data visualization platforms can empower teachers to create engaging science resources that align with curriculum goals. Without such interventions, the gap in teachers' proficiency will continue to hinder efforts to fully integrate digital technologies into science classrooms, thereby limiting students' exposure to 21st-century learning opportunities.

The results of this research indicated that secondary school science teachers expressed a positive agreement with the strategies proposed for addressing deficiencies in digital technology proficiency, achieving an overall mean score of 3.39, which surpasses the criterion mean of 2.50. This

suggests that science teachers acknowledge the significance of ongoing professional development initiatives, including in-service training, workshops, and professional development programs that incorporate digital pedagogy. This finding is consistent with the conclusions drawn by Tondeur et al. (2018), who highlighted that focused professional development and training in digital technology pedagogy are essential for enhancing teachers' digital competence. Likewise, Scherer et al. (2021) observed that educators who engage in organized digital professional development demonstrate increased confidence and capability in integrating digital tools into their instructional practices.

Strategies such as mentorship, professional learning communities, and collaborative projects were also acknowledged as effective approaches for enhancing teachers' digital proficiency. This suggests that peer support and collaboration foster shared learning, motivation, and exposure to innovative teaching strategies. According to Trust and Whalen (2020), collaborative approaches such as professional learning communities (PLCs) and peer mentoring play a vital role in sustaining digital integration in schools, as they enable teachers to exchange experiences and resources. In a similar vein, Cifuentes-Faura (2023) reported that fostering mentorship and teacher collaboration creates a culture of continuous learning and helps to close gaps in digital skills across varying school contexts. The results highlight the significance of having access to infrastructure, dependable internet connectivity, and collaborations with edtech firms and universities in addressing digital proficiency disparities. Science teachers expressed strong agreement that ICT resource centers, open educational resources (OERs), and incentives serve as effective facilitators for digital integration.

Conclusion

The integration of digital technologies into secondary school science teaching possesses the transformative ability to improve the quality of

learning by increasing student engagement and enhancing overall learning outcome. From the viewpoint of science teachers, digital resources like simulations, virtual laboratories, online materials, and collaborative platforms create opportunities to render abstract scientific ideas more concrete, interactive and relevant. It is important to note that this transformation is significantly contingent upon the teachers' readiness, skills, and preparedness to embrace and implement digital technology innovations in their teaching methodologies. Findings from science teachers' perspectives emphasize both opportunities and challenges in digital technologies integration for science teaching. While teachers recognize the benefits of using digital technologies for curriculum delivery and learner engagement, gaps in infrastructure, access to digital technologies and proficiency in creating digital resources is essential for driving sustainable transformation in science teaching and learning. Integrating digital technologies into science classrooms should extend beyond merely providing hardware and software; it must also prioritize equipping teachers with the essential skills, confidence, and pedagogical frameworks required for effective utilization. The viewpoints of science teachers emphasize that significant integration can occur when training, collaboration, and institutional

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- Adeoye, A. O., & Oyeleye, T. A. (2024). Digital learning tools and science education: backing align to foster a supportive environment. Therefore, effective digital transformation in secondary school science teaching must adopt a comprehensive approach covering infrastructure, capacity development, and ongoing policy support to guarantee a lasting influence on teaching and learning.
- Recommendations**
- The following recommendations were stipulated for the study;
1. Government and school authorities should prioritize the supply of modern hardware and software digital technologies to enhance quality science teaching in secondary schools.
 2. Regular professional development programmes, including workshops, seminars, and online courses, should be organized to enhance science teachers' proficiency in creating and utilizing digital technology resources.
 3. Schools should encourage and support the integration of digital technologies into classroom practice by providing incentives, technical support, and collaborative platforms for teachers to share best practices.
 4. Policymakers should institutionalize mentorship, peer-learning programmes, and ICT resource centers as part of a structured approach to strengthen teachers' digital competencies.
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