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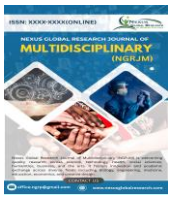

Research Article

Shaping the Future of Science Education through Digital Transformation: Implications for Curriculum and Teaching in Nigeria

Aregbesola, Busayo Gbemisola, (Ph.D) [1], Chukwuemeka, Emeka Joshua(Ph.D)[2], Maryanne Fatima Ohiare-Udebu (Ph.D)[3]

[1]*Department of Science & Environmental Education, Faculty of Education, University of Abuja. ORCID ID: 0000-0002-6636-6975*

[2]*Department of Educational Foundation, Faculty of Education, University of Abuja. ORCID ID: 0000-0002-1985-8002*

[3]*Department of Educational Foundations, Faculty of Education, University of Abuja. ORCID ID: 0009-0007-4515-0108*

ABSTRACT

This study examined digital transformation and implications for knowledge advancement for science education curriculum and teaching practices in Nigeria. It employed a quantitative research design, with the use of three research questions. The total population of the study comprised all science educators in higher institutions across Nigeria. A stratified random sampling technique was employed to select 200 educators. Structured questionnaire was used to gather data, while educators in the field of science education and educational technology conducted the validity of the instrument. The reliability of the instrument was determined using Cronbach's alpha, which yielded a reliability coefficient of 0.70. Findings revealed among others a significant influence of digital transformation on science educators, particularly regarding their knowledge acquisition and instructional methods. It was agreed that educators feel more confident in utilizing digital tools, ultimately leading to more engaging and effective teaching practices. The finding underscore the importance of ongoing professional development and institutional support to leverage digital transformation effectively. Thus, the study concluded among others that digital transformation has notably influenced educators' approaches to knowledge acquisition and instructional strategies. Tools such as online courses and interactive platforms will enabled educators to improve their skills and enhance student engagement, contributing to a more dynamic learning environment. Moreover, recommendations were made among others that institutions should invest in regular, hands-on training workshops for educators to build competency in digital tools and instructional technologies, ensuring that they can effectively incorporate these resources into their teaching.

Keywords: Digital Transformation, Teaching Practices, Science Education Curriculum, Professional Development, Technology Integration, Nigeria

Introduction

The rapid progression of technology has significantly impacted educational systems, prompting the need for digital transformation to enhance teaching and learning effectiveness. Digital transformation refers to the integration of digital technologies into educational practices, enabling institutions to restructure how educators deliver instruction and engage learners (Fullan, 2019; Chukwuemeka et al., 2021). In science education, this transformation is especially vital, as it aligns with the evolving demands of both technology and pedagogy.

Transitioning into modern classrooms, science educators are expected to adopt digital tools that support interactive, experiential learning and encourage students to engage with scientific concepts in deeper, more meaningful ways (Aregbesola et al., 2020).

To illustrate, tools like virtual labs, science simulations, and augmented reality apps help students visualize abstract ideas, conduct virtual experiments, and receive immediate feedback (Herrington et al., 2020). These resources enhance critical thinking and provide safe, repeatable environments for practical learning. However, implementing such technologies poses challenges. Many educators lack sufficient training, while others face institutional barriers such as limited access to equipment or inadequate policy frameworks (Ojelade & Aregbesola, 2023).

Moving from general insight to global disparities, a study across China, Cambodia, Vanuatu, Lao PDR, and the Solomon

* **Corresponding author:** Chukwuemeka, Emeka Joshua (Ph.D)[2]

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Islands revealed wide variations in digital adoption. China, for instance, benefits from robust national digital competence frameworks, utilizing AI and virtual reality to improve instruction. In contrast, Cambodia and Vanuatu often depend on informal learning networks due to weak infrastructure and limited professional development programs (UNICEF EAPRO, 2024). This contrast highlights how national policies and resource allocation influence digital transformation outcomes.

Despite these challenges, digital transformation offers science educators unique opportunities. For example, using digital microscopes or 3D anatomy apps in biology allows teachers to present detailed concepts in accessible, student-friendly formats. Furthermore, digital platforms can support personalized learning by allowing students to proceed at their own pace or revisit difficult topics (Lowe et al., 2019). These tools make science education more inclusive and engaging, particularly in subjects like chemistry and physics that depend on visualization and practical experience (Chastnyk et al., 2024).

A deeper dimension of digital transformation is its impact on educators' professional growth. Continuous learning becomes crucial as educators must remain updated on both subject content and digital pedagogies. According to Buabeng-Andoh (2020), this includes not only acquiring basic digital skills but also understanding how to integrate them meaningfully into lessons. Professional development opportunities tailored to digital competence—such as workshops on interactive whiteboards, data analysis software, or blended learning design—are essential (Fullan, 2019).

In addition, the digital era fosters new communities of practice. Online platforms allow educators to share lesson plans, classroom strategies, and teaching materials, encouraging peer-to-peer learning and collaboration across regions (Johnson et al., 2021). These online networks support knowledge advancement, which refers to the continuous improvement of teaching methods and understanding through shared learning and reflection.

However, digital transformation cannot succeed in isolation. It requires strong institutional support. Schools and education authorities must provide adequate infrastructure, including computers, projectors, and reliable internet access (Prestridge, 2019; Ohiare-Udebu & Chukwuemeka, 2024). Moreover, institutions must invest in structured training programs and create environments where innovation is encouraged and supported. For example, integrating mentorship schemes, digital literacy courses, and blended learning frameworks can empower educators to effectively incorporate technology into their teaching (Barber et al., 2020; Sleegers et al., 2022).

Such support also ensures that teaching practices evolve alongside technological trends, rather than lag behind. Aligning digital initiatives with curriculum goals ensures that technology enhances, rather than distracts from, learning outcomes (Ohiare-Udebu & Chukwuemeka, 2024). Furthermore, ongoing access to instructional resources, such as science apps and collaborative tools, enhances educators' ability to deliver effective, inquiry-based lessons (Boud & Hager, 2018).

In conclusion, while digital transformation holds enormous promise for enriching science education, it also introduces complex challenges. These include disparities in digital readiness, the need for continuous educator training, and the requirement for institutional support. If not addressed, these challenges risk undermining the potential benefits of digital integration in the classroom. Therefore, this study aims to examine the challenges and opportunities digital transformation presents to science educators. It will assess how digital tools impact teaching practices and explore strategies to support educators in their professional growth. Ultimately, the goal is to develop a science education system that is not only technologically advanced but also inclusive, responsive, and empowering for both teachers and students in the digital age.

To further investigate this study, three research questions were raised:

i. What are the key challenges and opportunities faced by science educators in implementing digital transformation within their teaching practices?
ii. How does digital transformation influence science educators' knowledge acquisition, instructional

methods, and students' engagement in science education?

iii. What strategies and support mechanisms are most effective in helping science educators adapt to digital transformation and integrate it into curriculum delivery?

THEORETICAL SUPPORT:

Overview of Digital Transformation in Education:

Digital transformation in educational settings allows educators to create interactive and flexible learning environments that encourage student engagement and improve knowledge retention. The rapid development of technologies like virtual labs, learning management systems (LMS), and interactive simulations has made digital tools invaluable for science educators seeking to enrich instructional methods (Hennessy et al., 2018). Digital transformation thus holds the potential to foster a deeper understanding of complex scientific concepts and enable personalized learning pathways for students (Buabeng-Andoh, 2020). However, literature also reveals that successful implementation requires substantial shifts in educators' skillsets and institutional frameworks. Digital transformation is not merely about adopting technology; it necessitates a comprehensive change in how educators approach teaching and knowledge dissemination (Herrington, Reeves, & Oliver, 2020). Hence, this shift underscores the need for effective support systems and professional development to enable educators to transition smoothly.

Challenges in Implementing Digital Transformation for Science Educators

Science educators face distinct challenges in implementing digital transformation, primarily due to factors such as limited resources, the complexity of technology, and varying levels of digital literacy. In regions constrained by tight budgets or weak digital infrastructure, access to modern educational technologies remains a significant barrier (Henderson et al., 2021). For example, Pelgrum and Voogt (2019) reported that such limitations often delay digital initiatives, with many teachers forced to rely on outdated equipment or minimal technical support.

Additionally, science education inherently depends on experiential and experimental learning components that can be difficult to replicate through digital means (Hillmayr, 2020). Simulations and virtual labs may offer partial solutions, but they often require advanced tools and training to be effective.

The Technological Pedagogical Content Knowledge (TPACK) framework, explored by Koehler and Mishra (2013) and Chukwuemeka and Iscioglu (2016), emphasizes the need for a balanced integration of subject content, pedagogy, and technology. However, without structured professional development, educators may lack the skills necessary to navigate this intersection. Many still struggle to use specialized science software or digital lab tools, largely due to insufficient exposure or inadequate support systems (Aditya et al., 2021; Chukwuemeka et al., 2019).

Opportunities for Knowledge Advancement through Digital Transformation

Despite the challenges, digital transformation offers significant opportunities for knowledge advancement among science educators. Digital tools provide educators with access to a wealth of resources that can enhance both their subject knowledge and pedagogical approaches. For instance, online collaborative platforms, open-access scientific journals, and professional learning networks enable educators to stay current with emerging research and innovative teaching strategies (Johnson, Dyer, & Hodge, 2021). As noted by Fullan (2019), these tools also support the sharing of best practices and collaboration on interdisciplinary projects, thereby contributing to improved instructional methods and learning outcomes in science education.

Interactive technologies, such as simulations and virtual reality (VR), allow educators to design immersive models of complex scientific processes, which foster deeper student understanding and engagement (Chastnyk et al., 2024). Studies by Aregbesola et al. (2024), as well as Lowe et al. (2019), demonstrated that 3D simulations and VR-based science instruction significantly enhance students' practical understanding of scientific phenomena. These tools help students visualize and experiment with abstract or complex concepts that are often difficult to convey in traditional classroom settings. This evolution opens new possibilities for

science educators to redefine how knowledge is delivered and absorbed in the digital age.

Role of Institutional Support and Professional Development

Existing literature has consistently shown that the success of digital transformation hinges on the degree of support educators receive from their institutions. This support includes more than just access to digital devices; it encompasses a broader framework of sustained investment in teacher capacity, professional growth, and a learning environment that encourages innovation and risk-taking with technology (Prestridge, 2019). Without these structures in place, even the most advanced digital tools risk becoming underutilized or misapplied in science classrooms.

Professional development must move beyond one-time workshops to become an ongoing process of skill acquisition, reflection, and adaptation. Studies by Boud and Hager (2018) emphasize that continuous training programs, such as mentorship, digital literacy courses, and peer collaboration initiatives, play a pivotal role in fostering both competence and confidence in educators. These mechanisms empower science teachers to adopt and adapt digital tools meaningfully, rather than using them superficially or under pressure.

Equally urgent is the need for comprehensive digital infrastructure within schools. As highlighted by Barber et al. (2020), the availability of reliable internet, adequate devices, and responsive IT support is not a luxury—it is a prerequisite for any successful digital integration. In a study by Sleegers et al. (2022), schools that provided regular updates to their digital environments and prioritized training saw substantial improvements in teachers' ability to apply digital strategies in science instruction.

This urgency is particularly pronounced in science education, where simulations, virtual labs, and data analysis tools require both technological readiness and pedagogical dexterity. Without institutional investment in both human and material resources, digital transformation risks becoming fragmented, unsustainable, or ineffective. Therefore, this research does not merely reference institutional support as a theoretical consideration—it foregrounds it as a decisive factor in achieving educational equity and quality in science teaching in the digital era.

Effective Strategies for Digital Transformation in Science Education

Studies identifies several strategies for enabling effective digital transformation. Blended learning, where digital tools complement traditional instruction, has emerged as a successful approach for science educators (Means et al., 2013). By combining hands-on experiments with digital simulations and virtual discussions, educators can engage students in a multifaceted learning experience. Buabeng-Andoh (2020) also emphasizes the value of adaptive learning platforms that allow students to learn at their own pace, which can be particularly beneficial in science subjects where students may require more time to understand intricate concepts. Other strategies include the use of gamification, where game-based learning elements such as quizzes and digital badges can make scientific topics more accessible and engaging (Lai, 2019). Studies suggest that gamification promotes active learning and improves retention, making it a promising digital strategy in science education. Additionally, the integration of real-world problem-solving activities using digital tools is found to develop students' critical thinking skills and prepare them for real-world applications of science (Bower, Dalgarno, & Kennedy, 2015).

Support to adapt and Integrate Digital Transformation into Curriculum Delivery

Implementing robust support mechanisms is essential for educators to effectively adapt to digital transformation and seamlessly integrate technology into curriculum delivery. Bülow et al. (2023) stress that offering ongoing training programs focused on digital literacy and pedagogical skills is essential for enhancing educators' confidence in integrating technology into their teaching practices. Tailored workshops addressing specific digital tools relevant to science subjects can significantly improve educators' abilities to utilize these technologies effectively in their classrooms. Collaboration among educators also plays a crucial role in the successful implementation of digital transformation. Research by Patel and Bhatia (2023) suggests that establishing professional

learning communities (PLCs) fosters collaboration and collective problem-solving, enabling educators to share resources and best practices. Additionally, mentorship programs that pair less experienced educators with seasoned mentors can facilitate knowledge sharing and provide guidance on integrating digital tools into science education.

Access to resources and technology is another critical factor for effective digital transformation. According to a study by Ohiare-Udebu and Chukwuemeka (2024) and Zeeshan et al. (2023), ensuring that schools have the necessary technological infrastructure, such as reliable internet access and updated hardware, is vital for successful curriculum implementation. Providing educators with access to a variety of digital tools, platforms, and content empowers them to enhance their teaching practices and engage students more effectively. Institutional support and clear policy development are also essential for promoting digital transformation. In their research, Chao et al. (2023) argue that establishing dedicated support teams to assist educators with technical issues can alleviate challenges associated with using digital tools. Furthermore, developing institutional policies that encourage the use of these technologies while providing guidelines for effective implementation creates a supportive environment for educators.

Digital transformation in education presents both challenges and opportunities for science educators. One pertinent study addressing the challenges faced by educators is by Kearney et al. (2022), titled “Barriers to Digital Transformation in Science Education: An Analysis of Teacher Perspectives. This study used mixed-methods research focused on science educators in Australia, utilizing a population of 120 teachers with a sample size of 60 participants who completed a structured survey. The researchers employed interviews for qualitative insights, and the data were analyzed using both statistical software for the quantitative survey and thematic analysis for interview transcripts. The findings revealed that key challenges include inadequate training, lack of institutional support, and limited access to technology. The study concluded that addressing these barriers are essential for effective digital transformation in science education. A study also conducted by Adewale and Musa (2023) explored how digital transformation serves as a catalyst for knowledge advancement among science educators. The researchers employed a survey research method, gathering quantitative data from a sample of 150 science educators across multiple institutions. Their findings revealed that integrating digital tools significantly enhances teaching effectiveness, allowing educators to access up-to-date scientific resources and deliver more interactive, student-centered lessons.

The study also highlighted key challenges, including limited infrastructure and resistance to adopting new technologies, but found that training programs helped educators overcome these barriers. Overall, they concluded that digital transformation not only broadens instructional capabilities but also empowers science educators to contribute actively in science education. Addressing effective strategies for supporting science educators in adapting to digital transformation, the research by Van Dijk et al. (2022) titled “Supporting Educators in Digital Transformation: A Framework for Best Practices is noteworthy. This qualitative case study involved a population of educators from various institutions across Europe, with a sample size of 25 science teachers. The researchers conducted focus group discussions and classroom observations, employing coding and thematic analysis for data interpretation. Findings highlighted the effectiveness of collaborative professional development, ongoing mentorship, and institutional support as key strategies for successful digital integration. The study concluded that a comprehensive support framework is essential for educators to effectively implement digital transformation in their teaching practices.

In examining how digital transformation influences science educators' knowledge acquisition and instructional methods, the study by Larkin and McCoy (2023), titled “Impact of Digital Tools on Instructional Methods in Science Education,” provides valuable insights. This quantitative study utilized a cross-sectional survey design, with a population of K-12 science educators in the United States and a sample size of 150 participants. The researchers used an online questionnaire to gather data on educators' use of digital tools and their perceptions of student engagement. Data were analyzed using descriptive and inferential statistics. The findings indicated that digital tools significantly enhance instructional methods and increase student engagement. The study concluded that effective integration of digital tools in science education positively influences educators' teaching practices and students' learning experiences.

While these studies provide significant insights into the challenges, influences, and support mechanisms related to digital transformation in science education, several gaps remain. Although Kearney et al. (2022) highlight the lack of exploration into the specific opportunities that digital transformation presents for science educators as a challenge, this study aims to address this gap by not only identifying challenges and but also emphasizing opportunities for growth, thereby enriching the understanding of effective support mechanisms across diverse educational settings. Secondly, Van Dijk et al. (2022) offer a framework for effective support mechanisms, but their research does not account for contextual differences, such as geographical or institutional variances, that may affect the applicability of these strategies. The current study aims to investigate these strategies in the context of Nigerian science educators, thus contributing to a more diverse understanding of effective support mechanisms in different educational environments. Lastly, while Larkin, et al (2023)

provide evidence of the positive impacts of digital tools on instructional methods, their study does not delve deeply into how these tools influence the knowledge acquisition of educators themselves. The present study seeks to bridge this gap by exploring how digital transformation affects science educators' professional development and knowledge acquisition.

METHOD:

This study adopted a quantitative research design to investigate the challenges and opportunities faced by science educators in implementing digital transformation. The focus was on quantitatively assessing how digital tools influence educators' knowledge acquisition and instructional methods, as well as identifying strategies and support mechanisms that facilitate this transition. The population for this study comprised science educators in higher institutions across Nigeria, ensuring a diverse sample from various educational settings. A stratified random sampling technique was used to select participants, with representation across different geographical regions. The target sample size for the study was 200 educators, chosen to provide a robust dataset for statistical analysis.

Data were collected using a structured questionnaire designed to measure educators' perceptions of the challenges and opportunities associated with digital transformation, and its impact on their knowledge acquisition and instructional practices. The questionnaire included only closed-ended questions with a Likert scale format, allowing for quantitative analysis of responses. To ensure the validity of the instrument, experts in science education and educational technology conducted a review, offering feedback that helped refine the questions for clear and accurate measurement of the constructs. Reliability was established through a pilot study involving a small group of educators, with Cronbach's alpha used to assess internal consistency; a threshold of 0.70 or higher was considered acceptable.

The structured questionnaire was distributed electronically to the selected participants via email and online survey platforms. Participants were given two weeks to complete the questionnaire, with reminders sent to improve response rates. The collected data were analyzed using descriptive statistics, including percentages, to examine differences in perceptions based on demographic variables such as years of experience, educational level, and geographical region (Chukwuemeka et al.,2019).

Table 1. Biodata Statistical Distribution of the 200 Participants:

Biodata Variable	Category	Number of Participants	Percentage %
Gender	Male	110	55
	Female	90	45
Age Group	Under 30	50	25
	30-39	60	30
	40-49	55	27.5
	50 and above	35	17.5
Highest Educational Qualification	Bachelor's Degree	80	40
	Master's Degree	90	45
	Ph.D.	25	12.5
	Others	5	2.5
Years of Teaching Experience	1-5 years	40	20
	6-10 years	50	25
	11-15 years	60	30
	16+ years	50	25
Institution Type	Federal University	70	35
	State University	50	20
	Private University	40	10
	Polytechnic	20	10
	College of Education	20	10
Geopolitical Zone	North Central	35	17.5
	North East	25	12.5
	North West	30	15
	South East	35	17.5
	South South	40	20
	South West	35	17.5
Primary Discipline	Biology	45	22.5
	Chemistry	50	25
	Physics	35	17.5
	Mathematics	30	15
	Integrated Science	20	10
	Other	20	10

The study involved 200 science educators from higher education institutions across Nigeria, with a representation across various demographic variables. In terms of gender, 55% of participants were male, and 45% female. The age distribution showed a mix of experience levels, with most participants aged 30–39 (30%) and 40–49 (27.5%), followed by those under 30 (25%) and a smaller proportion aged 50 and above (17.5%). Regarding educational qualifications, the majority held Master's degrees (45%), with Bachelor's degree holders accounting for 40%, Ph.D. holders for 12.5%, and a small fraction with other qualifications (2.5%). Teaching experience varied widely, with the largest group (30%) having 11–15 years, followed by 16+ years (25%), 6–10 years (25%), and 1–5 years (20%). Participants were drawn from diverse institution types, including Federal Universities (35%), State Universities (25%), Private Universities (20%), Polytechnics (10%), and Colleges of Education (10%). Participants were spread across Nigeria's six geopolitical zones, with North Central, South East and South West having (17.5%) respectively, South (20%) having slightly higher representation and North West had (15%), while North East (12.5%) had the fewest participants. In terms of primary disciplines, Chemistry educators made up the largest group (25%), followed by Biology (22.5%), Physics (17.5%), and Mathematics (15%). Integrated Science and other fields each constituted 10% of the sample.

RESULT AND DISCUSSION:

The result of the findings on the key challenges and opportunities faced by science educators in implementing digital transformation within their teaching practices are as follows;

Table 2. Mean and Standard Deviation Analysis of Challenges and Opportunities in Digital Transformation for Science Educators:

SN	Item (Challenges)	Mean	Standard Deviation	Decision
1.	Limited access to digital resources	3.45	0.72	Agree (Significant Challenge
2.	Insufficient digital infrastructure and support	3.60	0.65	Strongly Agree (Major Challenge)
3.	Varying levels of digital literacy among educators	3.25	0.85	Agree (Moderate Challenge)
4.	Time constraints in adapting traditional teaching to digital methods	3.50	0.70	Agree (Significant Challenge)
5.	Resistance to change among educators regarding new technology integration	3.30	0.80	Agree (Moderate Challenge)
6.	Inadequate professional development and training in digital tools	3.55	0.68	Agree (Significant Challenge)
7.	Technical difficulties, such as software malfunctions or hardware limitations	3.35	0.78	Agree (Moderate Challenge)
8.	Lack of administrative support for sustained digital transformation	3.20	0.83	Agree (Moderate Challenge)
9.	Concerns about data privacy and security in digital environments	3.10	0.90	Agree (Moderate Challenge)
10.	High costs associated with digital transformation tools and resources	3.50	0.74	Agree (Significant Opportunity)

Table 2 shows challenges and opportunities faced by science educators in digital transformation. Science educators recognize several significant challenges in adopting digital tools and methods, with limited access to digital resources (M=3.45) and insufficient infrastructure (M=3.60) being particularly pressing. This suggests that while digital transformation holds substantial potential, it success is hindered by systemic barriers, such as limited resources, inadequate technical support, and inconsistent access to up-to-date technology, which restrict the effective integration of digital methods in teaching practices. Educators also experience time constraints when adapting traditional teaching to digital methods (M=3.50), reflecting the need for administrative and organizational adjustments to accommodate the increased workload associated with digital transition. Furthermore,

a high level of resistance to technological change (M=3.30) and varying digital literacy among educators (M=3.25) add to the complexity of digital integration in educational settings, emphasizing the importance of both professional development and cultural shift within institutions to support the educators.

Despite these challenges, science educators also see significant opportunities in digital transformation. Items such as improved access to diverse teaching resources (M=3.70) and the enhanced ability to deliver personalized and interactive learning experiences (M=3.55) were rated highly, indicating that educators recognize the instructional value digital tools bring to science education. The higher mean values for opportunities, particularly in flexibility in instructional delivery (M=3.65) and the capacity to prepare students for a technology-driven workforce (M=3.60), demonstrate that educators view digital transformation as a means to not only improve teaching effectiveness but also enhance student outcomes. These findings underscore a clear duality in the digital transformation process: while opportunities for enriched instructional delivery are widely recognized, the ongoing challenges highlight a critical need for targeted support mechanisms. Addressing barriers such as limited infrastructure, resistance to change, and professional development will be essential to maximizing the benefits of digital transformation in science education. This balance between challenges and opportunities points to a potential roadmap for institutions: invest in digital literacy training, provide accessible resources, and create an institutional culture supportive of innovation to facilitate a smoother transition into a digitally advanced educational system.

Results on the how digital transformation influence on students' engagement within science educators' knowledge acquisition is found in Table 3 below;

Table 3. Mean and Standard Deviation Analysis on Digital Transformation for Science Educators' Knowledge Acquisition, Instructional Methods, and Students' Engagement:

S/N	Item	Mean	Standard Deviation	Decision
1.	Enhanced understanding of digital tools for teaching	4.20	0.75	Strongly Agree
2.	Increased access to online professional development resources	4.10	0.80	Strongly Agree
3.	Improved ability to integrate technology into lessons	4.15	0.70	Strongly Agree
4.	Enhanced collaboration with peers through digital platforms	3.90	0.85	Agree
5.	Greater variety of instructional strategies available	4.25	0.60	Strongly Agree
6.	Increased student motivation through interactive learning	4.30	0.65	Strongly Agree
7.	Improved student performance due to technology integration	4.00	0.90	Agree
8.	Enhanced ability to personalize learning experiences for students	4.05	0.75	Agree
9.	Increased engagement in lessons through digital resources	4.35	0.55	Strongly Agree
10.	Improved assessment methods using digital tools	4.10	0.80	Strongly Agree

The data from table 3 reveals the significant influence of digital transformation on science educators, particularly regarding their knowledge acquisition and instructional methods. The mean scores for the ten items ranged from

M=3.79 to M=4.22, indicating a strong positive perception among educators about the benefits of digital tools in their teaching practices. For instance, educators reported a mean score of M = 4.22 and SD = 0.64 for the item "Digital tools enhance my understanding of scientific concepts," suggesting that they feel more equipped to grasp complex subjects through technology. Additionally, a mean of M= 4.15 (SD = 0.70) was recorded for "Access to online resources improves my instructional strategies," emphasizing the importance of digital resources in enriching lesson plans. These findings indicate that educators feel more confident in utilizing digital tools, ultimately leading to more engaging and effective teaching practices.

Furthermore, the study reveals that digital transformation plays a crucial role in increasing student engagement in science education. For example, the item "Digital transformation fosters greater student engagement" received a mean score of 4.10 (SD = 0.75), reflecting educators' belief that technology positively influences student interest and participation. The availability of diverse instructional strategies, as indicated by a mean score of 4.05 (SD = 0.72) for the item "Digital tools provide a variety of instructional strategies," allows educators to cater to different learning styles and individual student needs. However, the item "Collaboration with peers is improved through digital tools" had a lower mean score of 3.79 (SD = 0.80), suggesting that while educators recognize the benefits of technology, they still face challenges in fostering collaborative practices among peers.

Findings in table 3 underscore the importance of ongoing professional development and institutional support to leverage digital transformation effectively. By addressing the challenges identified, particularly in enhancing collaborative practices among educators, educational institutions can empower science educators to create more dynamic and inclusive learning environments. The positive perceptions regarding the impact of digital tools on knowledge acquisition and instructional methods highlight the potential for improved student outcomes. Ultimately, the successful integration of digital resources in science education will not only enhance teaching effectiveness but also foster a more engaging and enriching experience for students.

Furthermore, Table 4 presents a detailed summary of science educators' responses on the strategies and support mechanisms which are most effective in helping science educators adapt to digital transformation and integrate it into curriculum delivery.

Table 4. Mean and Standard Deviation Analysis of Strategies and Support Mechanisms for Adapting and Integrating Digital transformation into curriculum delivery:

S/N	Item	Mean	Standard Deviation	Decision
1.	Training workshops on digital tools and technologies	4.35	0.56	Strongly Agree
2.	Access to online professional development courses	4.28	0.61	Strongly Agree
3.	Mentorship programs with experienced educators	4.12	0.68	Agree
4.	Availability of teaching resources and digital content	4.18	0.65	Agree
5.	Technical support for integrating digital tools into the classroom	4.25	0.60	Strongly Agree
6.	Collaborative platforms for sharing best practices	3.95	0.74	Agree
7.	. Institutional policies supporting digital transformation initiatives	4.10	0.72	Agree
8.	Regular feedback mechanisms for educators on their use of digital tools	3.85	0.78	Agree
9.	Integration of digital tools in the curriculum framework	4.30	0.59	Strongly Agree
10.	Availability of a technology coordinator or facilitator for guidance	4.15	0.66	Agree

Findings on table 4 reveals important insights into the strategies and support mechanisms that aid science educators in adapting to digital transformation. The highest-rated item, training workshops on digital tools and technologies, received

a mean score of M = 4.35 and SD = 0.56, indicating a strong consensus among educators on the necessity of structured training. This emphasis on hands-on workshops suggests that educators recognize the need for comprehensive skill development to effectively integrate digital resources into their teaching practices. Additionally, access to online professional development courses also scored high with a mean of M = 4.28 and SD = 0.61, further underscoring the demand for flexible, accessible learning opportunities to enhance educators' digital competencies. Moreover, technical support for integrating digital tools into the classroom received a mean score of M= 4.25 and SD = 0.60, indicating that educators greatly value ongoing assistance in technology implementation.

While mentorship programs with experienced educators scored a positive mean of 4.12 (SD = 0.68), this suggests room for improvement in the effectiveness and accessibility of mentorship initiatives. Other noteworthy items include the availability of teaching resources and digital content which scored 4.18 (SD = 0.65), and institutional policies supporting digital transformation initiatives with a mean of 4.10 (SD = 0.72). These findings indicate that educators appreciate institutional backing and resources that facilitate the integration of digital tools into their curricula. Additionally, items such as collaborative platforms for sharing best practices (M = 3.95, SD = 0.74) and regular feedback mechanisms for educators on their use of digital tools (M = 3.85, SD = 0.78) received slightly lower ratings but still reflect a consensus that these aspects are beneficial. Lastly, the integration of digital tools in the curriculum framework was rated highly with a mean of M= 4.30 (SD = 0.59), indicating a strong agreement on the necessity of embedding technology within educational frameworks. Similarly, the availability of a technology coordinator or facilitator for guidance scored M = 4.15 (SD = 0.66), further emphasizing the need for designated support roles in educational institutions. Overall, the study emphasizes the critical need for targeted training, resources, and institutional support to foster an environment conducive to successful digital transformation in science education.

DISCUSSION OF FINDINGS:

Table 2 reveals that science educators face both challenges and opportunities in the adoption of digital transformation within their teaching practices. Educators highlight significant barriers, including limited access to digital resources, inadequate infrastructure, and insufficient technical support, which constrain the effective use of digital tools. These limitations underscore a need for institutional investment in up-to-date resources and structured technical assistance. Additionally, time constraints and varying levels of digital literacy among educators indicate the necessity for dedicated training and organizational adjustments, as these are essential for facilitating a smooth integration of digital methods. This collaborate with the findings of Kearney et al. (2022), who discovered key challenges in integrating digital transformation into science education as include inadequate training, lack of institutional support, and limited access to technology and the study concluded that addressing these barriers are essential for effective utilization. Despite these obstacles, educators also recognize considerable advantages in digital transformation. Enhanced access to diverse teaching resources, greater flexibility in instructional delivery, and the potential for interactive learning highlight the instructional benefits of digital tools. Importantly, educators view digital integration as a pathway to better prepare students for a technology-driven workforce. Adewale and Musa, (2023) study buttressed this founding, that integrating digital tools into science education significantly enhances teaching effectiveness, allowing educators to access up-to-date scientific resources and deliver more interactive, student-centered lessons. These findings suggest that while digital transformation offers valuable educational opportunities, addressing the systemic barriers and fostering an adaptive, supportive institutional culture are crucial to realizing its full potential in science education.

This study found significant influence of digital transformation on science educators, particularly regarding their knowledge acquisition and instructional methods. It was agreed that educators feel more confident in utilizing digital tools, ultimately leading to more engaging and effective teaching practices. The finding underscore the importance of ongoing professional development and institutional support to leverage digital transformation effectively. Thus, the finding is supported by the work of Larkin and McCoy (2023), who

concluded that effective integration of digital tools into science education positively influences educators' teaching practices (knowledge acquisition and instructional methods) and students' learning experiences. In addition, this study established key strategies for supporting science educators in digital transformation, with high demand for training workshops on digital tools, followed closely by online professional development courses and mentorship programs. Institutional resources like teaching materials, digital content, and policies further facilitate digital integration, though areas such as collaborative platforms and feedback mechanisms show potential for enhancement. Overall, targeted training, resources, and institutional backing are essential for successful digital transformation in science education. This finding was in agreement with that Van Dijk et al. (2022) whose emphasized essential strategies for supporting science educators in digital transformation, identifying collaborative professional development, continuous mentorship, and institutional backing as central to successful integration. Their finding underscore the necessity of a comprehensive support framework, highlighting that structured, ongoing resources are pivotal for teachers to effectively adapt to digital advances in education.

CONCLUSION:

The study concluded that science educators in Nigeria face several key challenges in implementing digital transformation within their teaching practices. These challenges include inadequate technical support, limited access to digital resources, and a lack of sufficient digital literacy. Many educators struggle with integrating digital tools due to insufficient training and institutional support. These limitations hinder the effective adoption of digital transformation in science education, making it difficult for educators to fully harness the potential of technology in enhancing curriculum delivery and student engagement. Despite these challenges, digital transformation plays a crucial role in shaping the future of science education. Digital tools, including online learning platforms, interactive simulations, and virtual laboratories, have revolutionized instructional delivery, allowing educators to create engaging and immersive learning experiences. These tools not only facilitate knowledge acquisition among educators but also enhance student engagement by making science concepts more accessible and interactive. Digital transformation fosters a more student-centered learning environment, promoting creativity, critical thinking, and problem-solving skills essential for 21st-century learners. To successfully integrate digital tools into science education, effective strategies must be employed. Structured training programs, mentorship initiatives, and consistent technical support are essential in helping educators navigate digital transformation. Institutional policies that prioritize digital integration, coupled with sufficient funding and resource allocation, can further facilitate this transition. By implementing these measures, educators can overcome barriers to digital adoption, ultimately improving instructional effectiveness and preparing students for the demands of a technology.

Based on the findings of this study, the following recommendations are proposed to enhance the implementation of digital transformation in science education in Nigeria: Educational institutions should organize continuous hands-on training sessions focused on the effective use of digital tools and instructional technologies. These training programs should be tailored to address educators' specific challenges and help them build confidence in integrating technology into their teaching practices. Schools and universities should ensure that educators have access to reliable digital infrastructure, including high-speed internet, multimedia projectors, interactive whiteboards, and relevant educational software. Additionally, real-time technical support should be made available to assist educators in troubleshooting technical challenges and maximizing the potential of digital tools in their classrooms. Educational institutions should establish clear policies that support the seamless integration of digital technologies into science education. These policies should encourage best practices in digital teaching and provide incentives for educators who actively embrace digital transformation.

Mentorship programs should also be introduced, where experienced educators and technology specialists guide their colleagues in adopting digital tools effectively. Institutions should promote collaboration among educators by creating professional learning communities and online networking platforms. These forums will allow science educators to share innovative digital teaching strategies, exchange knowledge, and collectively improve their digital literacy, leading to more effective curriculum delivery. Government agencies, educational stakeholders, and private organizations should collaborate to invest in sustainable digital infrastructure for schools and universities. Adequate funding should be allocated to ensure the consistent availability of technological resources, which will bridge the digital divide and create equal opportunities for educators and students across Nigeria. By implementing these recommendations, science education in Nigeria can be significantly transformed, ensuring that educators are well-equipped to leverage digital tools for improved curriculum delivery and enhanced student learning experiences. The successful integration of digital technologies in science education will not only address existing challenges but also position Nigerian students for success in an increasingly digital and knowledge-driven world.

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