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DIGITAL TRANSFORMATION IN TEACHING: THE PREPAREDNESS OF IN-SERVICE TEACHERS IN NIGERIA FOR THE FOURTH INDUSTRIAL REVOLUTION (4IR)

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ABSTRACT: *The Fourth Industrial Revolution (4IR) has significantly transformed education, necessitating a revision of technology-based teaching methods. The research examines the readiness of in-service teachers in Nigeria for digital transformation in education, emphasising their digital literacy, access to technology, and capacity to incorporate digital tools into pedagogy through systematic literature reviews. The findings reveal a modest level of preparedness: while numerous educators exhibit basic digital abilities, significant deficiencies exist in advanced competences deemed essential for digital pedagogy, such as content production and collaborative online learning. The research delineates significant obstacles like inadequate training, restricted access to digital resources, and infrastructure deficiencies, particularly in rural regions. It also examines the impact of institutional support and professional development initiatives on enhancing teacher preparation. The findings underscore the necessity of focused interventions, such as policies that offer comprehensive digital literacy training, enhanced investments in educational technology, and changes that incorporate technology into teacher education curricula. The study contributes to the expanding dialogue on digital transformation in education and offers pertinent stakeholders strategic insights to enhance the digital readiness of teachers in Nigeria in light of worldwide trends.*

KEYWORDS: Digital Literacy, Digital Competencies, Digital Transformation, In-Service Teachers, Nigeria, Teacher Preparedness.

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INTRODUCTION

Digital transformation has been adopted by several industries, serving a pivotal role in fostering innovation in fields like education. E-learning and globalisation in the Fourth Industrial Revolution (4IR), characterised by artificial intelligence, big data, and networked systems, are fundamentally transforming educational institutions worldwide to use various digital gadgets (Schwab, 2017). Educators, as purveyors of information, must adapt to evolving technology demands to equip students for future employment in an unpredictable work market. The exodus of in-service teachers in poor nations like Nigeria to utilise these instruments for educational benefit—a factor that remains unverified—indicates a doubtful degree of readiness.

Globally, digital transformation in education is seen as a crucial element for achieving 21st-century learning competencies, including creativity, collaboration, and critical thinking. In affluent nations, the educational environment has evolved due to the implementation of technology such as learning management systems, virtual classrooms, and adaptive learning aids (OECD, 2020). Countries like Finland and South Korea have established national policies to enhance educators' digital competency, resulting in improved teaching results and increased student engagement (Collins & Halverson, 2018).

The educational industry in Nigeria has begun to undergo digitisation, albeit at a sluggish pace. Initiatives like as the National Digital Economy Policy and Strategy (NDEPS) aim to cultivate a digitally proficient workforce and enhance ICT in education (Federal Ministry of Communications and Digital Economy, 2020). Notwithstanding these endeavours, the integration of digital devices in classrooms has been inconsistent. Certain schools, particularly those in metropolitan settings, possess modern resources; nonetheless, several rural regions are deficient in infrastructure, appropriate curricula, qualified educators, and internet access (Adewale, 2022). This gap underscores the need of assessing the readiness of in-service educators for digital transformation.

The preparedness of in-service educators for digital transformation is crucial for effective technology integration in education. As we go through the Fourth Industrial Revolution (4IR) as digital tools increasingly reshape educational methodologies globally, the role of teachers as catalysts for change in this transformation is paramount. However, in Nigeria, there are significant deficiencies in teachers' preparedness to adopt and utilise these technologies effectively in their classrooms. (Okebukola, 2020). Although many Nigerian teachers possess fundamental digital literacy abilities, they often lack the advanced pedagogical and technological competences necessary for the effective integration of digital tools into their teaching practices. Consequently, they have difficulties in creating captivating and student-centered learning experiences.

Structural disparities exacerbate the situation. Teachers in rural and disadvantaged areas have more challenges due to limited access to essential infrastructure such as computers, internet, and energy. These disparities not only restrict teachers' access to specialised professional development but also sustain inequitable education, so greatly disadvantaging these pupils. The inconsistent use of technology throughout the system jeopardises the inclusion of Nigeria's educational reforms as the digital gap expands.

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The ramifications of this readiness deficit are profound. Improved training is essential; instructors will not effectively utilise technology to enhance learning outcomes without enough training and resources. The result may be distracted pupils, worse educational outcomes, and a failure to equip learners with the skills necessary for success in a digital economy. The inadequacy of instructors jeopardises the potential of technology to revolutionise education and undermines the nation's broader development initiatives necessary to align Nigeria's education system with global norms. These difficulties require resolution. Teacher preparation for digital transformation must occur on several fronts, equipping educators with the requisite knowledge, skills, and resources. This include the integration of comprehensive professional development programs, the provision of access to digital infrastructure, and the eradication of regional disparities. By enacting these steps, Nigeria can enable its educators to lead the digital revolution of education, striving for a resilient learning environment for all students, irrespective of their geographic or socio-economic conditions. This action is essential for achieving educational parity and is also vital for positioning Nigeria as a competitor in the global arena influenced by the Fourth Industrial Revolution (4IR).

Therefore, it is essential to assess the preparedness of in-service educators for digital transformation for several reasons. Initially, it provides a comprehensive overview of instructors' preparation, highlighting both their strengths and flaws. Secondly, it aims to inform policymakers and stakeholders about the systemic modifications necessary to provide educators with digital resources. This aligns with the worldwide trend towards technology, ensuring that Nigerian instructors are adequately prepared to impart 21st-century abilities. In the age of the Fourth Industrial Revolution, digital literacy is vital rather than optional. Educators are required to operate and acquire knowledge in a progressively digital classroom where technology facilitates collaboration, promotes individualised learning, and fosters creative teaching methods (UNESCO, 2021). This study aims to address the deficiencies in teacher readiness, which are essential for facilitating advancements in digital transformation within Nigerian education.

This study aims to accomplish three primary objectives that underpin the initiative for integrating digital transformation in the instruction of in-service teachers in Nigeria. The objective is to examine literature to assess the present digital literacy levels of the instructors, namely their proficiency in using digital technologies for communication, content creation, and classroom administration. Understanding their baseline digital proficiency is essential for determining areas requiring focused treatment. Secondly, it examines the socio-economic, institutional, and human factors influencing teachers' readiness to participate in digital instruction. It aims to uncover systemic constraints (e.g., infrastructure deficiencies) and facilitating factors to promote digital adoption by examining these variables. Third, it delineates the obstacles faced by scouts in relation to in-service teachers, including inadequate training, resource scarcity, and insufficient institutional support, while offering pragmatic methods to surmount these challenges and enhance preparedness for digital transformation. To achieve these objectives, the study poses two central research questions: (1) What is the current level of preparedness of in-service teachers for digital transformation in Nigeria? and (2) What are the main barriers to digital teaching in Nigerian schools? The study’s scope focuses exclusively on in-service teachers at the primary, secondary, and tertiary education levels, highlighting their digital literacy, access to resources, and available institutional support. It also accounts for Nigeria’s diverse educational landscape, particularly

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the disparities in access to infrastructure and professional development between urban and rural settings, ensuring that findings and recommendations are contextually relevant.

METHODOLOGY

This study used the systematic literature review (SLR) technique to evaluate in-service teachers in Nigeria about digital transformation in education. The SLR process will involve a systematic identification, eligibility criteria, and critical assessment of peer-reviewed academic publications, policy documents, and empirical studies from 2019 to 2024. A comprehensive search of Scopus, Google Scholar, and other databases was conducted utilising keywords such as digital transformation, teacher readiness, Nigeria, and Fourth Industrial Revolution. The selection of pertinent material was restricted to peer-reviewed publications, reports, and case studies concerning teacher digital literacy, the pedagogical integration of technology in Nigerian education, and the infrastructural obstacles to technology integration within that context.

The data extraction was directed by theme categorisation and encompassed the identification of digital skill deficiencies, contextual obstacles to professional advancement, and resource accessibility. The observations provided practical insights and recommendations, concluding the evaluation based on the most recent contextual difficulties and evolving elements affecting Nigeria's education sector. This methodology guarantees that the research issue is addressed with rigour, transparency, and relevance to the subject matter.

The systematic literature review (SLR) technique is warranted for its capacity to provide a thorough and evidence-based synthesis of current research regarding the preparedness of in-service teachers in Nigeria for digital transformation. Their comparative advantage lies in methodically aggregating data from many sources, allowing a more nuanced comprehension of issues such as digital literacy, infrastructure deficits, and training requirements. Systematic Literature Reviews (SLR) provide transparency, repeatability, and take into account pertinent contemporary studies. Its dependence on current literature may constrain novel discoveries about unexamined elements or contextual subtleties, however. The calibre of evidence from various research may vary, requiring a thorough evaluation of aggregated results.

THEORETICAL FRAMEWORK

The Digital Competency Framework on Global Digital Literacy Standards

The Digital Competency Framework, developed by the European Commission's Joint Research Centre, has emerged as a pivotal tool in shaping digital literacy standards worldwide (Gilster, 1997). Introduced initially as DigComp 1.0 in 2013, the framework aimed to define and assess the digital competencies required for personal, professional, and societal engagement. (Karsenti et al., 2020) Over time, it has evolved, with DigComp 2.0 in 2016 refining its conceptual elements and DigComp 2.1 in 2017 elaborating on proficiency levels and practical applications (Karsenti et al., 2020). The framework identifies five key areas of digital competence: information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. Each area encompasses specific

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competencies, defined by learning outcomes and proficiency levels, ranging from foundational to highly specialized expertise. (Karsenti et al., 2020) (Nabhan, 2021) The DigCompEdu framework, released in 2017, outlines the essential competencies required for the effective integration of technology in education, further extending the framework's reach (Sáez et al., 2020).

The Digital Competency Framework serves as a comprehensive structure for understanding and enhancing digital skills across Europe. It functions as a reference for citizens, educators, and policymakers, enabling them to assess and develop the digital capabilities necessary for personal, professional, and civic engagement. The framework's impact extends beyond Europe, as communities of practice and online training programs worldwide adopt its principles to foster digital competency development. (Sáez et al., 2020)

As technological innovations continue to transform the labor market and societal norms, the Digital Competency Framework plays a crucial role in ensuring that current and future citizens are equipped with the digital skills required to navigate the digital age. By aligning teaching practices and educational programs with the framework's standards, educators can prepare learners for the challenges of tomorrow, empowering them to exercise critical judgment in their use of digital technologies (Karsenti et al., 2020). This study on the Digital Competency Framework is highly relevant to the study on Digital Transformation in Teaching: The Preparedness of In-Service Teachers in Nigeria for the Fourth Industrial Revolution. The Digital Competency Framework provides a comprehensive structure for understanding and developing the digital skills required for both personal and professional engagement in the digital age.

As the fourth industrial revolution continues to transform the labor market and the skills that employers are seeking, the Digital Competency Framework can serve as a valuable reference for assessing and enhancing the digital competencies of in-service teachers in Nigeria. The framework's five key areas of digital competence - information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving - are directly applicable to the needs of educators in the 21st century. By aligning the professional development of in-service teachers in Nigeria with the standards and proficiency levels outlined in the Digital Competency Framework, the study can better prepare them to effectively integrate technology into their teaching practices and equip their students with the digital skills necessary for success in the fourth industrial revolution. Furthermore, the Digital Competency Framework's emphasis on digital citizenship and critical thinking in the use of digital technologies is highly relevant to the Nigerian context, where the digital divide and the need for digital literacy among educators and students are pressing concerns.(Karsenti et al., 2020)

By leveraging the insights and guidelines provided by the Digital Competency Framework, the study on Digital Transformation in Teaching can develop a more comprehensive and informed approach to assessing and enhancing the digital competencies of in-service teachers in Nigeria, ultimately contributing to their preparedness for the fourth industrial revolution. The insights and guidelines provided by the Digital Competency Framework can inform the development of a comprehensive and evidence-based approach to assessing and enhancing the digital competencies of in-service teachers in Nigeria. (Marais, 2023).

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This study on the Digital Competency Framework is highly relevant to the study on Digital Transformation in Teaching: The Preparedness of In-Service Teachers in Nigeria for the Fourth Industrial Revolution. The Digital Competency Framework provides a comprehensive structure for understanding and developing the digital skills required for both personal and professional engagement in the digital age.

The framework for digital competence outlines five essential areas for thriving in the digital age. **Information and Data Literacy** enables individuals to locate, evaluate, and manage digital information effectively. **Communication and Collaboration** focuses on using digital tools for interaction, teamwork, and participation in society. **Digital Content Creation** emphasizes developing and editing content while respecting copyright and licensing standards. **Safety** addresses protecting devices, personal data, and privacy, promoting digital well-being. Lastly, **Problem Solving** involves identifying challenges and using digital resources to resolve them. Together, these areas form a holistic approach to mastering skills vital for modern digital engagement.

Digital Competence Frameworks provide structured models outlining the essential skills, knowledge, and attitudes required for effective engagement with digital technologies. These frameworks serve as benchmarks for cultivating digital literacy across various sectors, particularly in education (Digital Competence Framework for Citizens (DigComp), 2017). In the educational context, DCFs guide educators in integrating digital tools, enhancing learning outcomes, and equipping students with the necessary skills for the digital age (Sáez et al., 2020). As noted in (Karsenti et al., 2020), digital competency is crucial in today's world as technological advancements reshape the labor market and employer expectations. Therefore, adapting teaching practices and programs to incorporate digital competency is vital for preparing future generations for the challenges ahead.

Prominent frameworks, such as DigCompEdu (DigCompEdu Framework, 2023), delineate specific competencies across several domains, including Professional Engagement, Digital Resources, Teaching and Learning, Assessment, Empowering Learners, and Facilitating Learners' Digital Competence. These domains encompass 21 specific competencies, each defined by learning outcomes and proficiency levels, ranging from foundational to highly specialized expertise (Digital Competence Framework for Citizens (DigComp), 2017). The framework acts as a valuable reference for citizens, educators, and policymakers in assessing and developing the digital skills necessary for personal, professional, and civic engagement (González et al., 2023). Other frameworks, such as the one mentioned in (Digital Frameworks, 2022), define competencies needed for various roles, including citizen, teacher, and connector. These frameworks often build upon existing models like the EU's DigComp 2.1 and DigCompEdu. The DigComp 2.2 framework, as described in (DigComp Framework, 2023), further elaborates on these competencies, providing detailed descriptions of skills such as browsing, searching, filtering, and evaluating data, information, and digital content. Similarly, UNESCO's **ICT Competency Framework for Teachers (ICT-CFT)** underscores technology's role in transforming education. It offers a guide for integrating ICT into teaching, emphasizing curriculum development, pedagogy, administration, and professional learning (UNESCO, 2018). These global frameworks set the stage for adopting contextualized models in regions like Nigeria.

In the digital age, Nigeria has been proactive in addressing the country's unique technological challenges. The National Digital Literacy Framework, developed by the National Information

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Technology Development Agency, (NITDA), has emerged as a comprehensive approach to fostering digital competencies that cater to Nigeria's socio-economic and infrastructural realities ("Nigeria Digital Economy Diagnostic Report," 2019). This framework aligns with global standards while emphasizing key areas such as information and data literacy, digital content creation, communication and collaboration, safety, and problem-solving. Recognizing the transformative potential of technology, the Nigerian government has also introduced the National Digital Learning Policy. This policy aims to establish a technology-driven learning environment, ultimately bridging the digital divide and empowering underserved communities (Idiodi, 2005) (Olanrewaju et al., 2021).

The importance of these initiatives cannot be overstated, as Nigeria grapples with persistent digital gaps, particularly in rural secondary schools and remote communities. Factors such as a lack of ICT strategies and policies, socioeconomic status, poor internet connectivity, electricity shortages, and high poverty levels have hindered digital inclusion in these areas. (Olanrewaju et al., 2021) To address these challenges, Nigeria must continue to develop comprehensive strategies that leverage digital technologies to provide equitable access to education and other essential services.

The Nigeria Digital Economy Diagnostic Report highlights five foundational pillars that are crucial for the country to reap the benefits of the digital economy: digital infrastructure, digital platforms, digital financial services, digital entrepreneurship, and digital skills. By focusing on these pillars, Nigeria can accelerate its progress towards a more inclusive and prosperous digital future. As Nigeria navigates its digital landscape, the adaptation of global frameworks to local needs has become a critical factor in driving meaningful change. The country's efforts to bridge the digital divide and empower underserved communities through initiatives like the National Digital Literacy Framework and the National Digital Learning Policy demonstrate a strong commitment to harnessing the power of technology for sustainable development. (Olanrewaju et al., 2021).

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Source: *European Commission, Joint Research Centre*
https://joint-research-centre.ec.europa.eu/scientific-activities-z/education-and-training/digital-transformation-education/digital-competence-framework-citizens-digcomp/digcomp-framework_en?etrans=es&prefLang=el

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Relevance of Digital Competency Framework to the Study on In-Service Teachers digital transformation in Nigeria

The assessment of in-service teachers' digital competence is pivotal to the success of Nigeria's educational digital transformation. Frameworks like DigCompEdu and the NDLF serve as tools for measuring teachers' readiness and identifying competency gaps. Understanding these gaps enables the design of targeted professional development programs to equip teachers with essential skills for integrating technology into teaching. Such programs are crucial for effective classroom management, content creation, and innovative pedagogy.

Furthermore, this study highlights factors influencing teachers' preparedness, including access to technology, institutional support, and attitudes toward digital teaching. By identifying barriers, such as infrastructural deficits and limited professional training, stakeholders can formulate strategies for enhancing teacher readiness. For example, investment in digital infrastructure and providing accessible training opportunities are essential steps toward building teacher capacity.

The implementation of digital competency frameworks in Nigeria faces challenges such as insufficient infrastructure, inadequate teacher training programs, and disparities in digital resource availability between urban and rural schools. To address these issues, there is a need for substantial investment in infrastructure, including internet access and digital tools. Additionally, continuous professional development programs focusing on practical digital skills are vital to building teacher confidence and competence.

Encouraging collaboration among educators through communities of practice can also promote knowledge-sharing and innovative teaching methods. This collaborative culture can help teachers navigate challenges and adopt best practices for integrating technology into teaching.

Digital Competency Frameworks provide a structured approach to enhancing digital literacy, especially in education. In Nigeria, frameworks like the NDLF, inspired by global models such as DigCompEdu, offer a pathway for improving the digital readiness of in-service teachers. By addressing infrastructural, training, and policy challenges, Nigeria can align its education system with global trends, ensuring that teachers are equipped to deliver 21st-century learning experiences. Such efforts will prepare students for a technology-driven future, contributing to national and global development goals.

Literature Review

Empirical Reviews

Apata (2023), explored the application of TPACK by English language teachers in Nigeria, emphasizing its role in enhancing teaching effectiveness. The findings highlight significant challenges, including inadequate training, limited digital resources, and insufficient institutional support. Teachers often recognize the importance of integrating technology but lack the skills and confidence needed for effective implementation. While the study provides essential insights, it relies heavily on self-reported data, introducing potential bias. Furthermore, it does not explore systemic factors, such as infrastructure deficits and policy challenges, that influence technology integration. Hence, there is a need for empirical

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research that evaluates actual classroom practices and examines the broader systemic factors affecting the integration of TPACK in teaching.

Adewale (2022), investigated ICT integration in rural Nigerian schools, identifying significant barriers such as inadequate infrastructure, limited teacher training, and restricted internet access. The study emphasized the need for equitable access to digital tools and resources to bridge the rural-urban divide in education. While the research provided valuable insights into the rural context, it neglected challenges specific to urban areas, such as inconsistencies in policy implementation and a lack of advanced teacher training opportunities. This oversight highlighted the necessity for a more balanced exploration of teacher preparedness across different geographical contexts in Nigeria.

Apata (2021), carried out a study that assessed the digital literacy levels of English language teachers in Ondo State and their impact on literacy development. Teachers demonstrated basic digital skills but lacked advanced competencies such as digital content creation and online collaboration. Barriers included limited professional development, inadequate access to digital tools, and lack of institutional support. The study provides a snapshot of teacher digital literacy but excludes perspectives on student outcomes, which are vital for evaluating the broader impact. It also does not account for demographic factors, such as age and teaching experience, which influence digital literacy levels. Future studies must adopt a holistic approach, incorporating student outcomes and demographic analyses to assess how digital literacy influences teaching effectiveness and literacy development.

UNESCO (2021), proposed strategies for global ICT integration in education, focusing on inclusivity and technology-driven pedagogy to enhance teaching and learning outcomes. The report provided broad recommendations for leveraging ICT to transform education systems but lacked specificity in addressing the infrastructural and logistical challenges prevalent in developing countries. This omission limited the applicability of the strategies in contexts with significant resource constraints. The study emphasized the need for tailored approaches that address the unique challenges of ICT adoption in low-resource environments, particularly in the education systems of developing nations like Nigeria.

Okebukola (2020), focused on teacher readiness for digital integration in Nigeria, revealing that while many educators possessed basic digital skills, they lacked advanced competencies required for effective pedagogical application. The study emphasized the importance of training programs to enhance teachers' technical and pedagogical capacities. However, it overlooked the role of teacher attitudes and their willingness to adopt technology, which are critical to successful implementation. This limitation underscored the need for further research into the psychological and motivational factors influencing teachers' integration of digital tools into their instructional practices.

The OECD, (2020) and Redecker (2017) explored advanced frameworks for digital literacy, such as DigCompEdu, designed to guide educators in integrating technology into teaching. These frameworks offered comprehensive strategies to enhance professional engagement, pedagogical innovation, and digital competencies. While effective in resource-rich environments, the frameworks required adaptation to resource-limited settings like Nigeria, where infrastructural and economic challenges hinder their practical application. The lack of context-specific recommendations highlighted the need for localized studies that tailor these global frameworks to the unique challenges faced by educators in developing nations.

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Collins and Halverson (2018), examined global advancements in technology-driven education, emphasizing the transformative role of digital tools in fostering personalized learning and collaboration. They highlighted the success of these models in developed countries, where access to infrastructure and resources enables widespread adoption. However, the study lacked applicability to resource-constrained settings like Nigeria, as it did not address the socio-economic and infrastructural challenges faced by educators in such contexts. The omission of these critical factors underscored the need for research that explores the adaptation of global technology-driven education practices to developing nations.

Digital Literacy and Competency Levels of In-Service Teachers in Nigeria

In the Fourth Industrial Revolution, educators must exhibit digital literacy and proficiency in an era where education is inextricably linked to digital technology. To evaluate in-service teachers' preparedness for technological progress and modern pedagogical demands in Nigeria, it is essential to assess their digital literacy skills. Consequently, digital literacy—the ability to access, evaluate, and produce information using digital technologies—facilitates teaching and learning processes, which is a crucial component of educational reform (UNESCO, 2021).

Digital technologies have rapidly evolved and transformed educational institutions worldwide. Digital transformation involves the application of digital technology to develop or alter processes, culture, and experiences in response to evolving needs. In education, this signifies the integration of digital tools, platforms, and pedagogical methods to enhance teaching and learning (Seufert et al., 2019; Yıldız, 2022). Fundamentally, it encompasses competencies in online searching, creation, and collaboration. Digital competencies refer to the essential skills, knowledge, and attitudes required to effectively and responsibly use digital technologies in personal, professional, and educational contexts. These competencies are foundational to navigating the digital landscape, enabling individuals to leverage technology for problem-solving, communication, collaboration, and content creation (Seufert et al., 2019; Yıldız, 2022; Audrin & Audrin, 2022; Joseph & Khan, 2020). Highly proficient instructors, particularly those specialising in digital literacy, has a distinct edge in employing technology to enhance instruction and foster an engaging educational experience (Apata, 2022). Consequently, the cultivation of digital literacy is crucial for effective digital transformation in education (Statti & Torres, 2020; Ftáčnik et al., 2020).

The publication represents a substantial endeavour to consolidate available data about the current status of teachers in Nigeria and indicates a crucial emphasis on enhancing the quality of educators within the Nigerian educational system. Urban educators possess a comprehensive understanding of fundamental ideas such as word processing and the Internet, but rural educators sometimes lack these essentials. In addition to lockdowns, digital learning options during the pandemic, including the creation of novel digital material, online collaborative learning, and the integration of technology in pedagogy, remain inadequately developed (Okebukola, 2020; Oyitso & Olomukoro, 2019).

In 2023, a poll indicated that 68% of urban teachers possess intermediate proficiency in fundamental digital technologies, compared to 32% of rural instructors. This disparity can be ascribed to inequitable access to resources and training. Nationally, just 45 percent of in-service teachers have participated in training seminars on digital literacy in the past two

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years, and hardly 25 percent express confidence in using technology to improve instruction. The lack of integration skills significantly affects student involvement and constrains contemporary teaching methods (Adeoye et al., 2023; Oluwole & Adebayo, 2023).

The digital gap in Nigeria is compounded by insufficient infrastructure. Research reveals that under 30% of public schools had operational computer laboratories or dependable internet connectivity, with fewer than 15% of institutions in northern Nigeria satisfying these standards. These infrastructure deficiencies impede teachers' capacity to employ digital skills and exacerbate the disparity between urban and rural educational systems (Okebukola, 2022; Adeoye et al., 2022).

Initiatives to improve digital literacy among in-service educators have been irregular. The Digital Literacy for Educators project predominantly focusses on metropolitan instructors, neglecting rural educators. Akinyemi et al. (2023) discovered that the majority of educators perceive the existing training as inadequate for meeting classroom requirements. Even among educators with fundamental digital competencies, the use of technology frequently stays confined to administrative functions. For instance, 60% of educators in Lagos State indicated competence with fundamental software, although just 25% employed these resources for interactive instruction (Oluwole & Adebayo, 2022).

Notwithstanding these limitations, focused attempts have shown advancement. A pilot program in Lagos and Abuja indicated a 25% enhancement in digital tool utilisation among participating educators over a six-month period. Furthermore, collaborations between the Universal Basic Education Commission and technology companies have demonstrated potential, especially for STEM instructors, with states indicating a 15-20% enhancement in digital proficiency over the last five years. STEM educators have significantly elevated digital literacy skills (45%) as a result of technology integration within STEM courses (Bamigboye, 2022).

The digital literacy and competency levels of in-service teachers in Nigeria indicate an urgent necessity for institutional improvements. Addressing the urban-rural gap necessitates investments in infrastructure, equitable allocation of resources, and customised training initiatives to tackle practical difficulties. Policymakers should promote technology adoption via strategic initiatives and cultivate collaborations with commercial organisations to expedite advancement. As Nigeria's education system progressively adopts technology-driven learning, it is essential to train instructors with requisite digital skills to prepare pupils for success in a digital future. Consequently, whereas Nigerian in-service educators demonstrate basic digital literacy, considerable deficiencies remain in advanced skills and equal resource access. Addressing these deficiencies requires comprehensive and inclusive initiatives that integrate infrastructure investment, professional development, and deliberate policy interventions to equip educators for the challenges of the Fourth Industrial Revolution.

Barriers and Challenges to Digital Transformation in Nigerian Education During the Fourth Industrial Revolution

The Fourth Industrial Revolution (4IR) underscores the incorporation of digital technology throughout several sectors, including education. The digital transformation of Nigeria's education system must be regarded as a strategic need to align with global trends, hence adapting learning and teaching procedures to these developments. It aims to enhance

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accessibility while promoting innovation. Significant obstacles and challenges impede the practical use of digital technology. Examples include low digital literacy, poor teacher training programs, socio-economic inequities, and systemic concerns such as policy gaps or governance challenges. Rural regions experience inadequate internet connectivity and limited access to equipment. Training possibilities are restricted and unavailable. Adewale (2022) asserts that the rural digital gap is exacerbating, since rural locations suffer from insufficient internet connectivity and urban schools are inadequately prepared. Despite the improved conditions in urban areas compared to rural regions, the circumstances remain detrimental for any educator residing and employed in Nigeria at now. Such infrastructural deficiencies exacerbate the digital divide, resulting in disparities in resource accessibility and professional development opportunities for teachers in rural vs urban areas. Research indicates that fewer than 30% of public schools in Nigeria have functional computer laboratories, and just 15% of schools in the northern regions have dependable internet connection (Okebukola, 2022). The deficiency of computers restricts the integration of digital technologies into educational instruction nationwide. This deficiency intensifies as downtimes escalate. The dependable utilisation of digital technology by schools cannot be guaranteed when energy is intermittently available.

Another critical issue is the insufficient levels of digital literacy among both educators and students. Research indicates that 68% of urban instructors have a moderate proficiency in fundamental digital technologies, however this percentage declines to only 32% for rural teachers (Adeoye et al. 2023). A significant number of instructors have not yet progressed to content creation or the utilisation of collaborative platforms. This skills gap impedes the capacity of digital technology to enhance learning in schools, particularly in underprivileged areas (Oyitso & Olomukoro, 2019).

The unpredictability and insufficiency of training programs have exacerbated these challenges. For instance, although programs such as the Digital Literacy for Educators project have attempted to address the digital skills deficit, their availability remains inconsistent, particularly in rural regions. Merely 45% of instructors nationally have participated in digital literacy training in the past two years, and just one-fourth have confidence in using technology into their teaching methods (Akinyemi et al., 2023). The absence of input indicates an urgent necessity for comprehensive, context-specific training programs aimed at equipping instructors with essential digital skills. This circumstance indicates that in impoverished rural schools, as well as at both educational and familial levels, where internet costs are often significantly higher than in affluent regions, it is exceedingly difficult for technology to penetrate the educational sphere. Consequently, many young individuals currently perceive their future opportunities for success in fields beyond agriculture or comparable practical occupations as severely restricted (Oluwole & Adebayo, 2023).

Notwithstanding Nigeria's numerous policy frameworks designed to promote digital transformation in education, implementation has been inconsistent. The National Digital Economy Policy and Strategy (2020-2030) emphasises the necessity of incorporating ICT in education; nevertheless, it lacks practical direction and financial mechanisms for successful implementation (Federal Ministry of Communications and Digital Economy, 2020). Governance challenges, including corruption and inefficiency, exacerbate the situation, resulting in the misallocation or underutilisation of resources (Okebukola, 2022).

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In addition, cultural and attitudinal opposition to change poses problems for digital transformation as well. A significant proportion of educators, particularly those of advanced age, resist adopting new technology due to concerns about obsolescence and a tendency to eschew digital tools for fear of their complexity. Conventional societal perspectives on education emphasise rote memorisation, often neglecting creative, technology-driven pedagogical approaches. This obstructs the acceptance of digital transformation programs (Oyitso & Olomukoro, 2019).

Despite these obstacles, significant potential exist for the advancement of Nigerian education into the digital era. Preliminary initiatives in Lagos and Abuja have shown results, with a claimed 25% enhancement in the utilisation of digital technologies among participating schools after six months. Collaboration with private sector entities has also demonstrated efficacy in delivering digital resources and training, particularly for STEM educators. Over the previous five years, an average rise of 15-20% in digital competence has been noted among educators in several states (Bamigboye, 2022). Global efforts, such as UNESCO's ICT in Education program, provide frameworks that Nigeria can follow to address local challenges.

Digital transformation in Nigerian education during the Fourth Industrial Revolution holds immense potential to enhance learning outcomes, foster innovation, and bridge educational gaps. Addressing the barriers of infrastructural deficits, skill gaps, socio-economic disparities, and policy challenges requires coordinated and sustained efforts from all stakeholders, including the government, private sector, educators, and international organizations. By leveraging these opportunities, Nigeria can create a more inclusive and digitally empowered education system, equipping students and teachers to thrive in the 21st century. With continued investment, strategic planning, and collaboration, the vision of a transformed educational landscape can become a reality in Nigeria in the fourth industrial revolution (4IR) era.

Strategies for Enhancing Teacher Preparedness for Digital Transformation in Nigeria During the Fourth Industrial Revolution (4IR)

The Fourth Industrial Revolution (4IR) underscores the importance of equipping educators with the necessary skills to integrate advanced digital technologies into teaching and learning. In Nigeria, teacher preparedness is central to achieving digital transformation in education. This process, however, requires a multifaceted approach that addresses gaps in skills, infrastructure, and policy implementation while fostering a culture of innovation and collaboration. Below are key strategies supported by research and evidence to enhance teacher preparedness for the 4IR.

1. Comprehensive Digital Literacy Training

Digital literacy forms the foundation of teacher preparedness for digital transformation. Training programs must cover essential skills such as navigating educational software, creating digital content, and managing virtual classrooms. Studies show that targeted training increases teacher confidence and competency in integrating technology into their teaching (Akinyemi et al., 2023). Training initiatives like the *Digital Literacy for Educators* should be scaled up to reach underserved areas, emphasizing the use of technology in pedagogy to improve student engagement and learning outcomes (Adeoye et al., 2023).

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2. Provision of ICT Infrastructure

Robust infrastructure is critical for enabling teachers to leverage digital tools effectively. Research highlights that fewer than 30% of Nigerian public schools have functional computer labs, and internet access remains a significant challenge, especially in rural areas (Okebukola, 2022). Addressing these deficits requires substantial investment in internet connectivity, power supply, and digital devices. Public-private partnerships (PPPs) can provide the funding and resources needed to establish ICT facilities in schools and communities (Bamigboye, 2022).

3. Embedding Digital Skills in Teacher Education Curricula

Pre-service teacher training programs must include comprehensive modules on digital literacy and the application of educational technologies. A recent review of teacher education programs in Africa suggests that embedding digital competencies into the curriculum prepares new teachers to navigate the challenges of the digital age (Oyitso & Olomukoro, 2019). Incorporating practical, hands-on training ensures that graduates enter the workforce with the confidence to integrate technology into their teaching.

4. Continuous Professional Development (CPD)

Ongoing professional development programs are essential for keeping educators updated on emerging technologies and teaching methodologies. Studies indicate that teachers who participate in CPD programs demonstrate improved pedagogical practices and higher student engagement (Fiona, 2023). CPD initiatives should include workshops, online courses, and peer mentorship programs to foster collaborative learning and skill sharing.

5. Addressing Socio-Economic Barriers

Socio-economic disparities in access to digital tools and training must be addressed to ensure equity in teacher preparedness. Subsidizing digital tools and internet access for low-income schools and educators can bridge the gap between urban and rural areas. Additionally, community-driven initiatives, such as digital literacy camps, can engage teachers, students, and parents in rural areas to build a supportive learning environment (Oluwole & Adebayo, 2023).

6. Strengthening Policy Implementation and Governance

While policies like the *National Digital Economy Policy and Strategy (2020–2030)* emphasize digital transformation in education, their implementation remains inconsistent (Federal Ministry of Communications and Digital Economy, 2020). A coherent framework for policy execution, backed by sustainable funding and accountability mechanisms, is crucial for success. Collaborations with international organizations can provide technical expertise and financial support to scale initiatives.

7. Fostering a Culture of Innovation

Building a culture of innovation within schools encourages teachers to experiment with digital tools and integrate them into their classrooms. Advocacy campaigns can promote the benefits of digital transformation, while leadership programs can empower school

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administrators to champion change. Recognizing and rewarding teachers who excel in using technology can further motivate adoption and innovation (Merritt, 2023).

8. Leveraging Public-Private Partnerships (PPPs)

Collaborations between the government, private sector, and non-governmental organizations can accelerate teacher preparedness by providing resources, training, and technical support. Technology companies, for instance, can supply software and devices, while NGOs can facilitate outreach programs in underserved areas. Such partnerships have proven effective in similar initiatives globally and can be adapted to Nigeria's unique context (Ruhalahti et al., 2023).

9. Monitoring and Evaluation

Regular assessments of teacher readiness and technology usage are essential for measuring progress and identifying gaps in implementation. Feedback from teachers should inform the design and delivery of training programs, ensuring that initiatives remain relevant and impactful. Monitoring systems should also track the impact of digital transformation on student outcomes, providing insights for further improvements (Kemmer et al., 2023).

Enhancing teacher preparedness for digital transformation in Nigeria requires a multifaceted approach that combines skill development, infrastructure investment, and policy alignment. By implementing comprehensive training programs, addressing socio-economic barriers, and fostering innovation through public-private partnerships, Nigeria can empower its educators to meet the demands of the Fourth Industrial Revolution. Sustained collaboration among stakeholders and a commitment to equity and innovation will ensure a digitally empowered teaching workforce ready to transform education for future generations.

IMPLICATIONS FOR POLICY, SDGS, AND FUTURE STUDIES

To achieve transformative digital integration, policies must prioritize equitable resource distribution, including robust infrastructure and comprehensive teacher training programs. Initiatives like the National Digital Economy Policy and Strategy (2020–2030) should be enhanced with clear funding mechanisms, accountability measures, and implementation frameworks to ensure widespread impact. Strengthening public-private partnerships can also amplify resources for digital education, particularly in underserved communities.

This study directly contributes to SDG 4 (Quality Education) by emphasizing inclusive and equitable access to digital learning. Equipping teachers with necessary digital skills aligns with SDG 9 (Industry, Innovation, and Infrastructure), fostering a future-ready workforce. Bridging digital gaps in rural and urban schools also supports SDG 10 (Reduced Inequalities), ensuring balanced opportunities for all learners.

Therefore, future researches should adopt longitudinal designs to evaluate the long-term impact of digital transformation initiatives on teaching efficacy and student outcomes. Comparative studies across regions, also, can offer deeper insights into localized barriers and success factors. Additionally, exploring the integration of emerging technologies, such as AI

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and VR, within Nigerian classrooms can expand understanding of how to further enhance digital education practices.

CONCLUSION

This study highlights the critical role of teacher preparedness in the successful integration of digital technologies within Nigeria's educational system amidst the Fourth Industrial Revolution (4IR). The findings reveal significant gaps in advanced digital competencies among in-service teachers, particularly in digital content creation and collaborative online learning, compounded by limited access to infrastructure and inconsistent professional development opportunities. While notable progress has been made in some urban regions, rural areas continue to face persistent barriers. Addressing these challenges through targeted interventions is imperative to equipping educators to effectively leverage digital tools and foster innovative, inclusive teaching practices across Nigeria.

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