Artificial Intelligence Adoption for Skills Development in Nigeria: A Systematic Review and Roadmap for TVET Transformation

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ABSTRACT

Artificial Intelligence (AI) is transforming education globally and presents a unique opportunity for developing nations like Nigeria to modernize their Technical and Vocational Education and Training (TVET) systems. This systematic review investigates the current state of AI integration in Nigerian TVET institutions, identifies key challenges, and proposes a policy-responsive roadmap for sustainable implementation. Guided by Diffusion of Innovations (DoI) theory, the study synthesized findings from 51 peer-reviewed articles published between 2019 and 2025 and thematically categorized them into five clusters: awareness and readiness, institutional capacity, implementation barriers, robotics and computational thinking, and ethical and policy considerations. The findings indicate strong interest in AI among stakeholders, but also expose critical gaps in infrastructure, lecturer expertise, policy coordination, and ethical governance. Using the DoI framework, the study highlights the importance of relative advantage, compatibility, complexity, trialability, and observability in shaping the adoption and diffusion of AI technologies across the TVET landscape. The proposed roadmap emphasizes inclusive stakeholder engagement, professional development, infrastructure investment, curriculum innovation, and the establishment of ethical and policy frameworks. This review provides data-driven insights for policymakers, educators, and stakeholders aiming to advance AI adoption for skills development in Nigeria.

Keywords: Artificial Intelligence, TVET, Nigeria, Diffusion of Innovations, Educational Technology, Skilled Workforce

INTRODUCTION

Artificial Intelligence (AI) integration into educational systems has become a global necessity, specifically for Technical and Vocational Training and Education (TVET), considering the job market's changing demands and the speed at which technology is developing. AI is pivotal in fostering personalized learning, predictive assessment, and curriculum alignment with Industry 4.0 standards (Stephen, 2021).

Countries like China support the advancement of AI by planning skills and tactics for developing talent, such as setting up specialized colleges and higher education courses. Then, it provides infrastructure by creating industrial centers that provide the hardware, software, and connectivity needed to spur industry innovation (Shiohira, 2021). Furthermore, the Swedish government's priorities for skill development include fostering industry-government collaborations to develop tertiary education in AI, promoting lifelong learning and career mobility, and establishing new positions that combine teaching and research (Vinnova., 2018). Moreover, considering the importance of AI in skills development, the Australian government developed a strategic framework for integrating AI into education, including AI awareness, advancing social and human welfare, and

ethical strategies (Commonwealth of Australia, 2023).

Nigeria, however, faces considerable barriers to adopting AI within its TVET landscape, despite mounting evidence that AI can bridge workforce skill gaps, improve employability, and support national development goals (Stephen, 2021). The country grapples with challenges such as limited infrastructure, fragmented policies, insufficient teacher training, and socio-cultural stigmas surrounding TVET programs (O. D. Bakare et al., 2023; Ukeje et al., 2024). Existing research on AI in Nigerian TVET remains fragmented, often descriptive, and lacking in comprehensive synthesis. A paucity of empirical and systematic reviews critically assesses the status, challenges, and future pathways of AI integration within this sector. These highlight this study's significance, providing a roadmap for proper AI integration in Nigeria's TVET programs for skilled workforce development.

This review adopts Diffusion of Innovations (DoI) Theory by Everett Rogers, (2003), as its guiding theoretical framework. DoI theory explains how, why, and at what rate new ideas and technologies spread through cultures and institutions. It identifies five key innovation attributes influencing the adoption process: relative advantage, compatibility, complexity, trialability, and observability. These attributes align well with the dynamics of integrating AI in TVET systems in Nigeria, where perceived advantage, contextual fit, and infrastructure readiness play vital roles.

In the context of Nigerian TVET, *relative advantage* corresponds to the perceived benefits of AI tools in improving teaching, learning, and administrative processes. *Compatibility* addresses how AI aligns with existing educational practices, cultural expectations, and national curricula. *Complexity* relates to challenges in implementing AI systems, especially in under-resourced environments. *Trialability* and *observability* highlight the importance of pilot programs and visibility of success stories to encourage wider adoption. DoI theory further emphasizes the roles of *change agents, communication channels,* and *social systems* in promoting or hindering innovation diffusion. These elements are critical in understanding institutional leadership, government policy, lecturer readiness, and student awareness in Nigerian TVET environments. Thus, this review aims to 1). Map existing research on AI integration in Nigerian TVET institutions, 2). Evaluate enabling and limiting factors through the lens of DoI theory, and 3). Propose a national roadmap that leverages innovation diffusion strategies for sustainable AI adoption in education.

METHODOLOGY

Using the PRISMA approach (Page et al., 2021), A systematic literature search was conducted, and relevant articles were retrieved from four central academic databases, including Scopus, Web of Science, ProQuest, and Google Scholar. Search terms included combinations of *("artificial intelligence" OR "AI" OR "AIED" OR "recommended system" OR "recommendation system" OR "adaptive learning" OR "prediction system" OR "student model" OR "machine learning" OR "intelligent tutoring system" OR "expert system" OR "learner model" OR "data mining" OR "learning analytics" OR "prediction model" OR "feedback system" OR "personalized learning" OR "automated evaluation" OR "automated assessment" OR "robot" OR "virtual agent" OR "algorithm" AND "TVET" OR "technical education" OR "technology education" OR "vocational education" OR "engineering education" AND "nigeria")* filtered for peer-reviewed articles between 2015 and 2025.

Articles' inclusion and exclusion criteria

Inclusion criteria were focused on AI applications in education or TVET in Nigeria, clearly defined data collection and analysis procedures, and discussion of challenges, opportunities, or ethical implications of AI in education. A total of 1787 records were retrieved, with 51 studies meeting all inclusion criteria after screening and de-duplication, as shown in Figure 1.
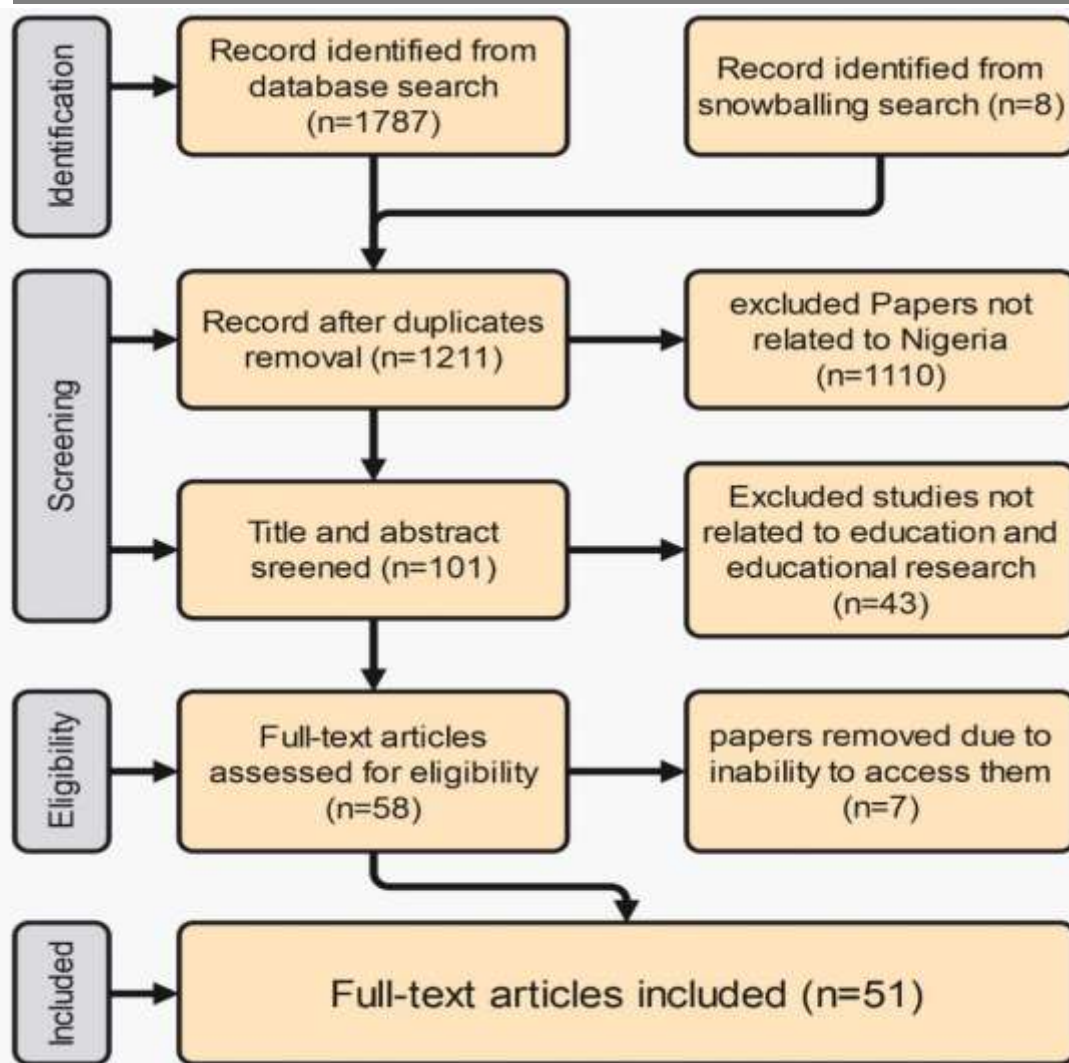
Figure 1: PRISMA data collection procedure.

Thematic Analysis

To extract and structure the underlying themes in the selected AI research literature from Nigeria, Braun and Clarke's (2006) A six-phase thematic analysis framework was employed. The process began with an in-depth familiarization phase, wherein the titles, abstracts, and keywords of all 51 documents were read and reread to identify recurring ideas and contextual nuances. This immersion informed the next phase, generating initial codes as shown in Table 1, where key terms related to educational capacity, technological awareness, implementation challenges, and ethical considerations were systematically extracted. Using these codes, themes were inductively identified by clustering conceptually related codes into broader categories. This procedure led to the formation of five overarching themes: (1) Awareness, Perceptions, and Readiness; (2) Lecturer Expertise and Institutional Capacity; (3) Challenges and Barriers; (4) Computational Thinking and Robotics Education; and (5) Ethical Concerns and Policy Gaps, as shown in Table 1.

The thematic boundaries were refined during the review by assessing the codes' external distinctiveness and internal consistency within each identified theme. To ensure analytical coherence and clarity, the themes were precisely defined and given names that encapsulated their distinct scopes. The complete coding and topic structure were finally combined into a comprehensive dataset to evaluate and discuss trends in AI integration in Nigerian educational research. This rigorous, qualitative analysis approach ensured depth and transparency in the qualitative analysis process.

Table 1: The themes, codes, and articles reviewed

Themes	Codes		Articles
1 Awareness, Perceptions, and Readiness	acceptance attitude toward AI awareness level beliefs about AI digital literacy	engagement familiarity with AI lecturer perception readiness student perception	(Ebekozien et al., 2024), (Ayanwale, Adelana, & Odufuwa, 2024), (Nja et al., 2023), (Orim et al., 2025), (Joseph et al., 2024), (Mbazu et al., 2024), (Oladipupo & Samuel, 2024), (Ayanwale et al., 2022), (Yusuf, Pervin, et al., 2024), (Orok et al., 2024)
2 Lecturer Expertise and Institutional Capacity	AI in testing automated grading competency curriculum development digital skill	faculty expertise faculty knowledge feedback systems infrastructure institutional readiness	(Ahmed et al., 2025), (Omeh et al., 2024), (Olugbade et al., 2024), (Ikudayisi et al., 2023), (Joseph et al., 2024), (Nannim et al., 2024), (Nurudeen et al., 2024), (J. Bakare et al., 2021), (Anyanwu et al., 2024), (Nnadi et al., 2024)
3 Challenges and Barriers	barrier challenge difficulty fragmented policy implementation issues	infrastructure limitation insufficient infrastructure lack of resources low budget resistance to change	(Sanusi et al., 2024), (Ofem et al., 2024), (Bolu et al., 2024), (Owan et al., 2023), (Oyelere et al., 2022), (Musa & Alabi, 2020), (Sharma et al., 2022), (Khan et al., 2024), (Ossai & Duru, 2022), (Gambo et al., 2021)
4 Computational Thinking and Robotics Education	Arduino STEM learning coding literacy computational thinking computer behaviour	digital skills learners outcomes programming robotics	(Nannim et al., 2025), (Yusuf, Noor, et al., 2024), (Yusuf & Noor, 2023), (Sunday et al., 2023), (Ahmad Muhammad et al., 2022), (Ikpeze et al., 2022), (Bessong et al., 2024), (Sunday et al., 2020), (Omeh et al., 2022)
5 Ethical Concerns and Policy Gaps	academic integrity, accountability, bias, data privacy, ethical use,	fairness legal moral concern policy vacuum regulatory framework	(Omeh et al., 2024), (Isiaku, Muhammad, et al., 2024), (Ayanwale, Adelana, Molefi, et al., 2024), (Isiaku, Kwala, et al., 2024), (Ofem et al., 2024), (Ugwu et al., 2024), (Unogwu et al., 2024), (Yusuf, Pervin, et al., 2024), (Ofem et al., 2024)

RESULTS AND DISCUSSION

Overview of Included Studies

The 51 articles included range between 2019 and 2025, as presented in Figure 2, indicating 2024 has the highest number of publications compared to the remaining years. This increase in publications shows how more interest in studies related to AI is progressing. More attention is now being paid to AI integration in the education setup.
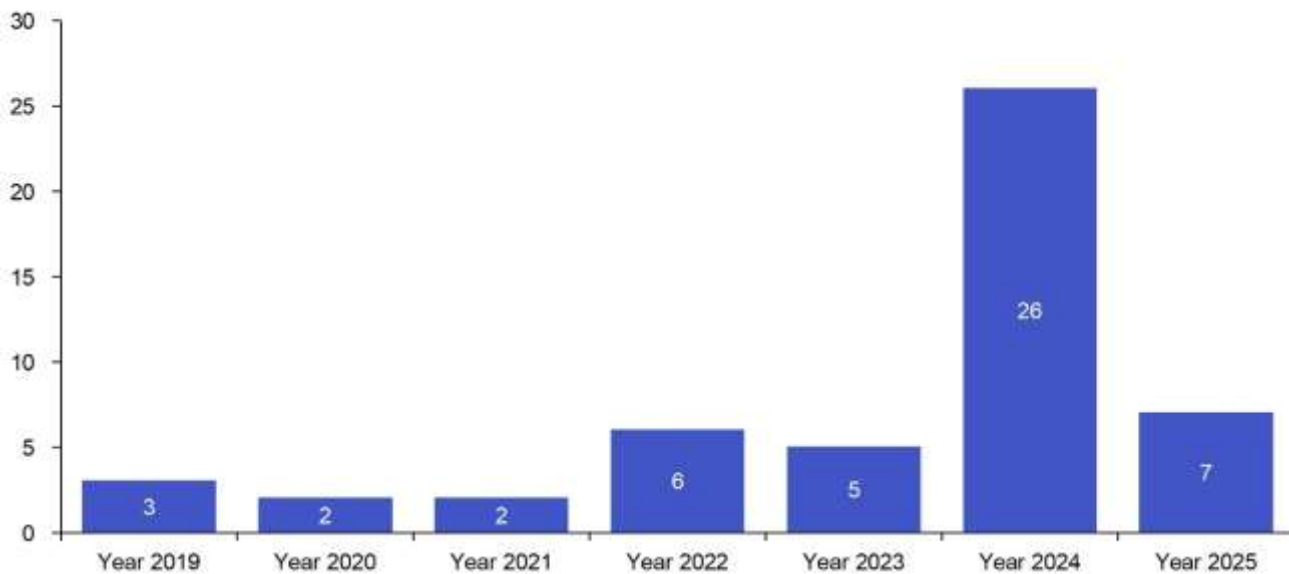
Figure 2: AI publications ranging from 2019 to 2025.

The 51 reviewed studies encompass a broad spectrum of researchers' contributions, including conceptual discussions, case studies, and empirical investigations that explored the nexus of education, TVET, and AI in Nigeria. Considering the analyzed articles, 44 (86%) were published between 2022 and 2025, reflecting a surge in AI research in Nigeria's TVET programs. This growth aligns with the global trend of educational technology adoption accelerated by the COVID-19 pandemic (Egara & Mosimege, 2024; Yauri et al., 2024). Many of these studies examined how Nigerian institutions responded to remote learning demands, revealing both innovation and limitations in existing digital infrastructure. Notably, the reviewed publications examined the transformative potential of AI in enhancing educational efficiency, with a specific focus on automated assessment tools, personalized learning pathways, and intelligent tutoring (Obada et al., 2024; Ukeje et al., 2024). This research advancement indicates a larger trend toward data-driven education and the potential contribution of machine learning to foster institutional resilience and student achievement.

TVET Stakeholders AI Awareness, Perceptions, and Readiness

The stakeholders' awareness, perception, and preparedness are critical elements in innovation adoption; they are progressively shaping the integration of AI into TVET for skilled workforce development. Studies reveal a high level of awareness and generally positive attitudes toward AI among Nigerian TVET students and teachers (Ayanwale et al., 2022; Joseph et al., 2024). However, this enthusiasm does not consistently translate into readiness, mainly due to limited digital literacy and the absence of structured capacity-building programs (Nja et al., 2023). These challenges align with the DoI theory's core constructs, such as *complexity* and *trialability,* indicating that perceived difficulty in using AI tools and the lack of opportunities to experiment with them are barriers to adoption. Moreover, the *relative advantage* of AI in improving learning outcomes is not fully leveraged due to weak institutional support and inadequate infrastructure. As Rogers (2003) noted, innovations spread more effectively when adopters perceive them as easy to use, advantageous, and observable in successful use cases. These insights underscore the importance of inclusive policies, structured professional development, and pilot programs that enhance technical competence, reduce complexity, and promote observable success, fostering AI's sustainable adoption in Nigeria's TVET system.

Lecturers' AI Expertise and Institutional Capacity

Effective AI integration in TVET depends significantly on lecturers' expertise and the broader institutional

environment. Research indicates that many lecturers lack the confidence and pedagogical knowledge required to deliver AI-enhanced curricula and remain skeptical about its potential benefits (Omeh et al., 2024). Furthermore, institutional shortcomings such as unreliable internet access, obsolete equipment, and inadequate technical support hinder innovation efforts (Ahmed et al., 2025). These limitations align with the *complexity and compatibility* attributes of innovation adoption. When an innovation is perceived as challenging to use or poorly aligned with existing institutional frameworks, the rate of adoption declines. Additionally, the absence of visible success stories and insufficient infrastructure reduces *observability and relative advantage*, further delaying institutional uptake. Additionally, systemic insights from bibliometric and machine learning analyses highlight the importance of institutional factors like class duration, infrastructure, and educational design in shaping successful AI adoption (Ikudayisi et al., 2023; Nnadi et al., 2024). Therefore, to fully realize AI's promise in TVET, investing in institutional infrastructure and improving lecturers' knowledge through ongoing professional development is imperative.

AI Integration Challenges and Barriers

Numerous structural and systemic challenges hinder the effective implementation of AI in Nigerian TVET institutions. These barriers include the absence of localized AI content, inadequate funding, limited stakeholder collaboration, and persistent resistance to change (Oyelere et al., 2022). Many institutions still lack coherent digital strategies to guide AI integration efforts (Owan et al., 2023). Furthermore, fragmented implementation approaches and weak national-level coordination have made it challenging to scale AI pilot initiatives (Bolu et al., 2024). These obstacles reflect poor *compatibility* of AI with local educational contexts, high perceived *complexity* of implementation, and insufficient *facilitating conditions* that promote *trialability and observability,* which are key determinants of successful innovation diffusion. Adoption rates are typically low in environments where innovation is not aligned with existing norms, infrastructure, or institutional culture. Nonetheless, research suggests that these systemic barriers can be overcome through participatory policymaking, culturally relevant AI content, targeted investment, and strategic planning to enhance the perceived *relative advantage* of AI, facilitating its broader acceptance and sustainability in the TVET sector (Sanusi et al., 2024).

Robotics and Computational Thinking in TVET

Promising innovations are emerging in project-based learning and robotics education, illustrating AI's transformative potential in Nigerian TVET. Tools such as the Arduino Robot Application (PARA) and mobile robotics kits have been shown to enhance programming skills, student engagement, and collaborative learning (Nannim et al., 2025). Likewise, low-cost educational robots like the Ikpeze robot offer scalable, accessible entry points into robotics for learners of different ages. These tools combine affordability with advanced features like vision and audio support, making them suitable for educational and applied research in fields like surveillance (Ikpeze et al., 2022). AI-powered educational games and virtual reality platforms have also demonstrated potential in enriching object-oriented programming instruction. By offering real-time feedback and intelligent tutoring, these tools foster immersive, student-centered learning environments and contribute to improved emotional engagement and academic outcomes (Sunday et al., 2023). These innovations illustrate high *relative advantages, observability, and trialability* attributes that encourage adoption. However, the lack of institutional support and the regional limitation of these projects suggest barriers to *compatibility and system-level readiness*. For such innovations to scale successfully, national frameworks must support infrastructure development, policy alignment, and professional training to ensure broader institutional adoption and long-term sustainability.

Ethical Concerns and Policy Gaps

As educational institutions strive to balance innovation with academic integrity, ethical concerns and policy

voids surrounding AI integration in TVET have become increasingly critical. Reviewed studies reveal that TVET lecturers urgently call for ethical frameworks that uphold data privacy, academic integrity, and transparency while still recognizing AI's potential to enhance personalized learning and student performance (Isiaku, Muhammad, et al., 2024; Omeh et al., 2024). Research further identifies pressing ethical dilemmas such as academic dishonesty, algorithmic bias, and the absence of a coherent national policy on AI in education. These gaps contribute to inconsistent implementation standards and expose both learners and institutions to ethical vulnerabilities (Ofem et al., 2024; Ugwu et al., 2024). A persistent lack of regulatory clarity has also been shown to erode trust in AI systems, particularly among educators tasked with integrating these tools into their teaching (Yusuf, Pervin, et al., 2024). Adoption is likely to stall when AI tools and practices are not perceived as ethically aligned with institutional values or societal norms. Additionally, the *observability* of transparent, well-regulated implementations and the *relative advantage* of responsible AI remain limited without clear policy frameworks. To promote ethical, scalable adoption of AI in Nigerian TVET, there is a need for culturally grounded policies and governance structures that build trust, ensure fairness, and support innovation in a socially responsible manner.

DISCUSSION

Synthesizing the literature reveals a fragmented yet gradually evolving AI ecosystem within Nigerian TVET. Using Diffusion of Innovations (DoI) theory as a guiding lens, the slow adoption of AI can be attributed to key factors such as high complexity, low compatibility with local contexts, and limited trialability across institutions. While there is growing awareness and interest in AI, especially heightened in the post-pandemic era among both students and educators (Joseph et al., 2024). A significant gap persists between awareness, institutional capacity, and actual implementation. Structural limitations, including inadequate funding, lack of strategic digital vision, and outdated infrastructure, continue to undermine the relative advantage and observability of AI innovations, thereby stalling wider diffusion (Bolu et al., 2024). As most institutions remain reactive in their digital transformation efforts, driven more by crisis-response than by forward-thinking innovation, administrative inertia and budgetary constraints further delay scalable, sustainable adoption (Ikudayisi et al., 2023). To catalyze widespread AI integration, systemic reforms must prioritize reducing complexity, enhancing contextual relevance, and fostering institutional environments that support experimentation and long-term investment.

Although there is demonstrable enthusiasm among students and select educators to embrace AI-driven teaching and learning tools, this enthusiasm is often short-lived due to a lack of institutional support, professional training, and coherent pedagogical frameworks (Nannim et al., 2025). Lecturers' anxiety over job displacement and the absence of structured incentives for continuous upskilling further discourages innovation in instructional practices (Yusuf, Pervin, et al., 2024). AI integration in TVET should not be limited to being a technical advancement. Instead, it calls for a systemic shift in pedagogy toward competency-based, student-centered, data-informed educational approaches that meet industry standards. When used correctly, AI can improve employment results, encourage real-time feedback, and increase customization (Ayanwale, Adelana, & Odufuwa, 2024; Yusuf, Pervin, et al., 2024). However, unlocking this potential requires multi-level coordination from institutional readiness to national policy enactment and ethical governance.

Pilot initiatives, such as deploying educational robots and adaptive learning platforms in selected institutions, demonstrate feasibility and student engagement but remain fragmented and lack scalability due to the absence of a national implementation framework (Bolu et al., 2024; Nannim et al., 2025). A recurrent recommendation across the literature is the urgent development of a National AI in Education Policy, establishing unified implementation standards, providing funding mechanisms, and addressing ethical boundaries in AI use (Omeh et al., 2024; Ugwu et al., 2024). Cross-sector stakeholder collaboration involving educators, policymakers, private industry, and learners is equally critical to co-create a resilient and inclusive sustainable AI within TVET.

Although Nigeria's path toward AI-driven TVET transformation is still in its infancy, key pillars such as growing awareness, recorded pilot innovations, and a growing corpus of empirical research suggest a clear course. Addressing infrastructure deficiencies, institutionalizing professional development, and enforcing ethical AI governance are essential for ensuring long-term impact. In addition to bridging the gap between ambition and reality, these steps will establish Nigeria's TVET industry as a competitive force in intelligent education.

PROPOSED ROADMAP FOR AI IN NIGERIAN TVET

A strategic roadmap must consider the innovation diffusion process across stakeholder groups to move Nigerian TVET institutions from fragmented experimentation to structured, scalable AI adoption. Using Diffusion of Innovations (DoI) theory as the guiding framework, the following tactical measures are proposed to enhance the relative advantage, compatibility, trialability, observability, and reduce the complexity of AI innovations within the TVET ecosystem.

Multi-Stakeholder Engagement for Social System Alignment

Successful innovation-diffusion depends on a supportive social system. Engaging key actors, including industry experts, educators, students, and policymakers through national AI forums and cross-sector consultation platforms, is vital for fostering collective ownership and ensuring that AI tools and policies are compatible with the values and needs of the Nigerian TVET sector. Collaboration enhances legitimacy and accelerates the acceptance of AI as a relevant educational innovation.

Continuous Professional Development to Reduce Complexity and Build Compatibility

The perceived complexity of AI technologies remains a significant barrier. To overcome this, national programs should focus on building AI literacy and pedagogical skills among TVET educators. Co-developed with technology providers and international partners, these training programs should emphasize practical application, interdisciplinary teaching, and change management. This ensures that AI integration aligns with existing teaching practices, increasing compatibility and lecturer confidence.

Infrastructure Investment to Enable Trialability and Observability

Reliable infrastructure enhances both the trialability and observability of innovations. Targeted investments in power supply, broadband internet, and AI-ready computing facilities are essential for TVET institutions to experiment with and showcase effective AI applications. Public-private partnerships can help alleviate funding burdens and ensure that pilots are visible, replicable, and scalable across diverse institutional contexts.

Curriculum Innovation to Enhance Relative Advantage and Compatibility

Embedding AI within TVET curricula ensures its relative advantage is perceived and experienced. AI should be integrated as a subject teaching data science, machine learning, and AI ethics, and as a teaching tool that supports experiential learning. This dual approach ensures students develop core competencies for Nigeria's emerging digital economy while aligning AI tools with current educational content and goals.

Development of Ethical and Policy Frameworks to Build Trust and Reduce Resistance

Ethical concerns and regulatory uncertainty hinder AI adoption by undermining trust, an essential component of social system readiness. A national AI-in-education policy is urgently needed to address data privacy, algorithmic bias, intellectual property, and institutional accountability issues. Such a framework would provide clear guidance and observability for ethical AI use and help institutional leaders and educators adopt AI responsibly

and sustainably.

CONCLUSION

This review comprehensively examined the current landscape of AI integration in Nigerian TVET and synthesized key findings from the literature. Framed through the Diffusion of Innovations, the study highlights that large-scale AI adoption is contingent upon improving the innovation's perceived relative advantage, ensuring compatibility with institutional goals and cultural contexts, and reducing the complexity of implementation. Despite growing interest and awareness among lecturers and students, AI implementation in Nigerian TVET remains fragmented due to inadequate infrastructure, limited technical expertise, and the absence of clear ethical and regulatory frameworks.

In contrast, international examples demonstrate that with coordinated investment and robust policy support, AI can be a powerful driver of pedagogical innovation, enhanced learning outcomes, and labor market alignment in vocational education. The proposed roadmap emphasizes five critical enablers of diffusion: inclusive stakeholder engagement, continuous professional development, infrastructural improvement, curriculum reform, and ethical policy frameworks.

For Nigeria to harness AI as a transformative force in its TVET sector, it must move beyond isolated experimentation and embrace a systemic, innovation-driven approach grounded in the principles of Diffusion of Innovations. Future research should empirically investigate the effectiveness of AI-based instructional tools on student performance, the cost-efficiency of such technologies in resource-constrained settings, and the socio-cultural dynamics of AI adoption. Given the limited volume of existing literature, a follow-up bibliometric analysis is recommended as more scholarly publications on AI in Nigerian TVET become available.

Conflict of Interest

No potential conflict of interest.

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