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Redefining Technical Education through Artificial Intelligence Integration: Pathways to Employability and Sustainability

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Abstract
Technical education has traditionally been central to producing skilled manpower for national development. However, outdated curricula and conventional teaching methods fail to meet modern labour market and industrial requirements. This failure results in skill gaps, graduate unemployment, and limited national competitiveness. Hence, this study focuses on redefining technical education through artificial intelligence integration as a pathway to employability and sustainability. AI offers innovative solutions through virtual simulations, AI-powered career guidance, enabling personalised, practice-oriented, and immersive learning experiences. These technologies enhance learners' technical competencies, engagement, and readiness for real-world workplaces, bridging the gap between educational training and labour market demands. Despite its potential, AI integration faces challenges including limited implementation costs and infrastructure, dependence on human instruction and overreliance on technology. Nevertheless, strategic adoption of AI in technical education can transform teaching and learning processes, align curricula with industry needs, and equip graduates with the skills required for participation in technologically driven economies. The study highlights AI as a critical tool for modernising Nigeria's technical education system, strengthening employability outcomes, and contributing to national and global sustainable development goals.

Keywords: Technical education, artificial intelligence, Redefining, employability and sustainability.

1. Introduction

Technical and vocational education in Nigeria has long been recognized as a foundational pathway for developing skilled manpower essential to national industrial development (Ajeniweni et al., 2024). Yet, despite the broad range of programmes offered across technical colleges, universities, vocational centres, and polytechnics, the system remains constrained by outdated pedagogical approaches that increasingly fail to align with modern industrial realities. This demonstrates that traditional instructional systems can no longer sustain national development, and therefore, Nigeria must embrace more technologically driven approaches.

Artificial Intelligence (AI) has been described as a technological field that produces intelligent systems capable of generating outputs such as decisions, forecasts, and content based on human-defined objectives (Nwosu et al., 2024). In the context of technical education, this capability enables dynamic, personalised, and practice-oriented learning experiences that traditional classroom-based teaching cannot provide. By incorporating AI, learners in technical programmes can move beyond rote learning and engage in realistic simulations, adaptive tutoring, automated assessment, and digital laboratory experiences that prepare them for actual workplace conditions. This shift supports improved graduate readiness for employment and entrepreneurship, aligning technical education with the needs of modern industries. Furthermore, integrating AI directly supports national and global development goals, as sustainable development demands continuous learning, innovation, and the ability to participate productively in technologically driven economies (Okorieocha & Ugwunali, 2025). Nigeria, like many countries, faces challenges such as unemployment, skill gaps, and educational deficiencies that hinder national competitiveness.

Therefore, this study examined the redefining of technical education through artificial intelligence as a pathway to employability and sustainability. The urgency of this shift is underscored by the rapid evolution of industries toward automation, digital processes, and smart manufacturing systems, all of which require workers equipped with new technological competencies.

2. Roles of Technical and Vocational Education and Training in Relation to Sustainable Development Goals

The Federal Republic of Nigeria (FRN, 2014) outlines Technical and Vocational Education and Training (TVET) as a vital educational pathway designed to

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equip learners with practical knowledge and employable skills. Its key purposes include: Developing a competent workforce in applied sciences, technology, and commercial fields, especially at the middle-level manpower stage, strengthening individuals' technical and vocational capacities to support growth in agriculture, industry, commerce, and the wider economy, laying a solid academic foundation for advanced professional training in engineering and other technology-based disciplines and producing skilled craftsmen, technicians, related personnel who possess entrepreneurial abilities and the capacity for self-sustained livelihood, and empowering young people with the knowledge and awareness required to adapt to the rapid and increasing technological advancements of modern society (FRN, 2014).

The Sustainable Development Goals (SDGs), with particular reference to Goal 4, underscore the importance of providing inclusive, equitable, and high-quality education while creating opportunities for continuous learning throughout people's lives (Nwuche & Enyia, 2024). This goal focuses on several major priorities:

I. **Universal Access to Technical, Vocational, and Tertiary Education:** By the year 2030, efforts are directed toward ensuring that all individuals regardless of gender can obtain affordable and quality education at the technical, vocational, and higher education levels. This accessibility is essential for empowering individuals with the competencies needed for self-development, career progression, and the effective application of sustainable practices (Nwuche & Enyia, 2024).

II. **Promotion of Sustainable Development and Global Responsibility through Education:** Goal 4 further aims to equip learners with the knowledge, values, and skills required to support sustainable development. This includes encouraging sustainable ways of living, nurturing a sense of global citizenship, advancing gender equity, upholding human rights, and fostering a culture of peace and non-violence. Education is also expected to promote appreciation for cultural diversity and acknowledge the role of different cultures in achieving sustainable development (Nwuche & Enyia, 2024).

III. **Strengthening the Teaching Workforce:** A major target under Goal 4 is the substantial increase in the supply of professionally trained teachers by 2030. This calls for stronger international partnerships to improve teacher education and professional development, particularly in developing and less-developed countries. Skilled educators are essential for delivering high-quality education and preparing learners with the competences needed for sustainability in the world of work (Nwuche & Enyia, 2024).

Despite these aspirations, employers often highlight a mismatch between the competences of technical education graduates and the practical skills demanded by industries. This indicates that many curricula lag behind technological innovations and evolving industry standards (Edo & Edo, 2025).

3. Concept of Artificial Intelligence

Artificial Intelligence (AI) is the branch of science and technology concerned with creating machines that exhibit intelligent behavior (Weber, 2023). It focuses on designing computer programmes capable of undertaking tasks typically requiring human intelligence. In this sense, AI seeks to imitate human thinking and empower systems to draw conclusions through data interpretation and the identification of patterns. Complementing this view, artificial intelligence is regarded as an advanced technological development designed to emulate diverse human capabilities, including language comprehension, pattern detection, reasoning, and learning from experience. By replicating these sophisticated cognitive processes, AI enhances automation and strengthens problem-solving capacities across various fields (Sheikh et al., 2023).

AI-enabled instruction provides opportunities for virtual learning environments, industry-linked curriculum updates, improved student performance tracking, and expanded access to practical learning even in the absence of adequate physical infrastructure (Alam, 2021). These possibilities reinforce AI as a strategic tool for strengthening technical education outcomes in ways that traditional approaches cannot. AI is fundamentally tied to human knowledge, judgment, and supervision. As Miao and Holmes (2021) observed, nearly all AI systems depend extensively on human expertise.

4. Innovative Applications of Artificial Intelligence in Technical Education

Artificial Intelligence has emerged as a powerful driver of change in multiple fields, including technical education. Its applications are increasingly shaping how teaching and learning are delivered in this field (Okorieocha & Ugwunali, 2025). Key areas of application include:

I. **Student-Focused and Personalized Learning Systems:** AI systems in technical education are designed to enhance teaching and learning process, and equip learners with 21st-century skills. By analysing individual needs and preferences, AI-powered platforms can deliver customised instruction that addresses "specific gaps in knowledge or competence" (Chen et al., 2021). For example, such systems can adjust the pace and complexity of courses in areas such as automobile technology, welding, or electrical/electronics to match each learner's ability.

II. **Simulated Training and Virtual Reality (VR):** Hands-on practice is vital in technical education, and

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combining AI with virtual reality allows students to practice in lifelike, risk-free environments. This approach lets learners in fields like automotive repair, construction, and healthcare performs tasks virtually, gaining practical skills without the financial or safety concerns of real-world practice. AI further enriches these simulations by making them "interactive and responsive to students' actions" (Martínez & Hernández, 2020).

III. **Automated Assessments and Feedback:** AI can enhance assessment processes by evaluating students' work against established standards and generating instant feedback. For example, AI-based tools are capable of assessing technical competencies in areas such as coding or graphic design through the analysis of "submitted projects" (García-Peñalvo et al., 2019). This approach not only reduces instructors' workload but also ensures that students receive timely and constructive feedback.

IV. **AI-Powered Virtual Tutors and Chatbots:** Beyond classroom teaching, AI-powered tutors and chatbots serve as round-the-clock learning assistants. They answer questions, explain concepts, and guide learners through coursework, which is particularly valuable in technical and vocational education where students often require support with "complex tasks outside regular teaching hours" (Zawacki-Richter et al., 2019).

5. Roles of Artificial Intelligence in Teaching and learning in Technical Education

Technical education is a key driver of economic growth, as it prepares individuals with industry-relevant skills required to succeed across diverse industries. However, the rapid advancement of technology, particularly in Artificial Intelligence (AI), has underscored the urgent need for educational systems worldwide to "adapt and evolve" (Edo & Edo, 2025). One such innovation is the use of Intelligent Tutoring Systems (ITS) in schools, which enables the creation of students' personalised learning tailored for specific needs. These systems assess learners' prior knowledge and learning pace, thereby facilitating a more individualised and effective educational experience (Ezeaku & Agu, 2025). Additionally, it can provide immediate feedback on students' mastery of technical concepts and practical skills, such as those in automobile engineering, welding, or electrical/electronics.

Moreover, artificial intelligence enables performance appraisal systems to monitor students' academic progress in a more interactive, personalised, and efficient manner. Through AI-driven tools, learners' performance can be analysed, constructive feedback provided, and areas requiring improvement identified, while simultaneously reducing lecturers' workload associated with repetitive grading and evaluation tasks. According to Nwaokugha and Abiakwu (2024), notable AI applications for assessment in technical education include automated marking and feedback systems, plagiarism detection software, natural language processing for analysing students' written work, virtual tutors and chatbots for learner support, as well as data analytics for curriculum improvement. In technical fields such as automobile, welding, and electrical/electronics education, these tools can be applied not only to theoretical assessments but also to evaluating practical competencies through simulations, digital logs, and performance tracking. By leveraging these applications, educators are able to deliver more customised and effective learning experiences, dedicating more time to hands-on instruction and workshop demonstrations rather than routine administrative tasks.

6. AI in Technical Education: Implications for Employability and Sustainability

Artificial intelligence, often defined as "the capacity of machines to perform tasks that typically require human intelligence," is increasingly being applied across multiple sectors, including education (Russell et al., 2021). Integrating AI into technical education not only addresses workforce skill gaps, but the adoption of AI in technical education has also become a critical necessity. Through AI-enabled platforms, learners can engage in interactive training environments, experience real-world simulations, and receive personalised feedback that enhances both theoretical understanding and practical skills (Wang & Huang, 2025).

By leveraging AI technologies, vocational and technical education institutions are better equipped to adapt to individual learning styles and provide targeted support that fosters mastery of complex concepts and hands-on skills (Cui & Fwuyuan, 2024). AI integration enables customised learning pathways, automation of routine instructional tasks, and data-driven insights that inform curriculum design and instructional planning. As industries continue to adopt advanced technologies, the demand for professionals proficient in "AI-related applications" becomes increasingly urgent, positioning its integration into technical training as both timely and essential for sustainable development (Shiohira, 2021). Beyond bridging the skills gap, "AI-based innovations" are enriching teaching methodologies in technical education. For instance, adaptive learning systems and "Intelligent Tutoring Systems (ITS)" apply AI to personalise educational resources based on learners' progress, creating flexible and effective pathways to competence (Woolf et al., 2020). Similarly, AI-powered simulations and virtual reality environments provide authentic, interactive training scenarios that replicate workplace settings, a vital component of vocational preparation. By transforming instructional delivery and aligning training with industry expectations, these innovations support the development of a workforce in the evolving labour market.

7. Challenges in Integrating AI into Technical Training

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Although "AI" presents significant opportunities for enhancing "technical education", its integration is confronted with multiple challenges. Key barriers include "high implementation costs," "inadequate infrastructure," and "resistance to technological change," as well as a mismatch between the competencies imparted by training programmes and the requirements of the labour market (Ayonmike et al., 2015). Uduafemhe (2021) further identified "inadequate funding of TVET institutions" and the "negative societal perception of vocational education" as major hindrances to AI adoption in Nigeria. Similarly, Shuaibu (2024) noted that in Africa, challenges extend to "a shortage of qualified trainers and AI experts," "insufficient infrastructure," and "ethical concerns" surrounding the deployment of AI technologies.

Ethical issues have also been raised. Adefolalu and Okebukola (2020) argued that AI use raises questions regarding "data privacy," "intellectual property," and "the authenticity of student work," since it may be difficult to determine the extent to which outputs are genuinely produced by students. Adeboye (2023) warned of the dangers of overreliance on AI, noting that although AI supports communication through suggestions, grammar checks, and content generation, students may become excessively dependent on these tools. This overdependence, according to Uteh and Iheukwumere (2024), could weaken the development of "critical thinking and problem-solving abilities," which are crucial for entrepreneurship. In line with this, Uzo (2021) emphasised the necessity for teachers and students to acquire "new competences" to effectively integrate AI into educational activities such as word processing. Other challenges of AI integration in technical education can be categorised as follows:

I. **Expensive Implementation and Upkeep:** The introduction of AI technologies demands heavy investment in hardware, software, and supporting infrastructure. Such costs are often prohibitive for vocational institutions that already operate under severe budgetary constraints. For instance, AI-powered simulators and adaptive learning platforms involve significant upfront expenditure and recurring maintenance costs, making them inaccessible to underfunded schools (UNESCO, 2019; Hussin et al., 2021).

II. **Shortage of AI Experts and Qualified Trainers:** Effective integration of AI requires trained experts capable of developing, implementing, and managing "AI-based educational programmes". Unfortunately, Nigeria faces a shortage of such professionals, and many educators lack the technical expertise to effectively apply AI tools in vocational training. Preparing trainers to operate and troubleshoot AI systems, including machine learning algorithms and AI-driven simulators, is both costly and time-consuming (García-Peñalvo et al., 2019), posing a challenge to fulfilling the "mission of technical education" to produce competent and innovative graduates.

III. **Risk of Overreliance on Technology:** A growing dependence on artificial intelligence may reduce human interaction and mentorship in vocational training. Since AI cannot adequately replicate essential soft skills such as teamwork, communication, and leadership, excessive reliance on technology could limit students' holistic development (Hussin et al., 2021).

8. Human Dependence and the Practical Limits of Contemporary Artificial Intelligence

Despite the widespread excitement surrounding Artificial Intelligence, its functioning remains fundamentally tied to human knowledge, judgment, and supervision. As Miao and Holmes (2021) point out, almost every AI system relies heavily on expertise inserted directly by humans. Linguists and phoneticians guide natural language processing systems, while specialists in traffic behaviour and driving supply the knowledge base for autonomous vehicles. In essence, AI does not operate independently of human input; it is built on it. Machine learning's dependence on humans goes even deeper. As Säuberlich and Nikolić (2018) explain, machine learning cannot create a complete AI system without support. Human decisions embed value judgments into every stage of AI development, making the idea of autonomous machine learning misleading (Säuberlich & Nikolić, 2018).

Although improving transparency in AI decision-making may provide certain benefits, Burt (2019) warns that such efforts can also introduce new risks. The limits of AI are also obvious in everyday experiences: personal digital assistants cannot engage in genuine conversation and often misinterpret basic commands. While AI can outperform humans in tasks such as pattern recognition or statistical reasoning, it performs far below human levels in areas like common sense, contextual understanding, and sustained dialogue. There is also growing evidence that the global momentum behind AI is slowing (Miao & Holmes, 2021). Practical challenges confirm these concerns, as fully autonomous vehicles navigating complex environments like Palermo or Delhi remain decades away, and image recognition tools still fail in simple scenarios (Mitchell, 2019). Overall, AI excels in tasks that humans often find challenging, yet it performs poorly in areas humans manage easily, such as self-directed learning, ethical judgment, and intuitive reasoning (Miao & Holmes, 2021). These realities underscore the need to recognise the essential and irreplaceable role of humans in shaping, guiding, and correcting AI systems.

9. Evaluating Perceptions and Evidence on AI Adoption in Technical Education

Idris et al. (2025) and Baharin et al. (2024) report strong student approval of AI-driven learning tools,

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with learners perceiving clear training benefits. However, teachers' perceptions reflect a more complex reality. Although instructors recognise the potential advantages of AI in teaching, many express concerns about their readiness to implement these tools effectively. Zary and Zary (2025) observed that teachers displayed limited practical understanding of AI applications, even within technology-focused vocational institutions in Germany. These findings point to an urgent need for structured professional development to equip teachers with the competence required to use AI meaningfully in TVET.

Stronger empirical evidence emerges from studies involving AI-supported simulators and Extended Reality systems designed to monitor and assess practical skills in real time. Lee et al. (2023) investigated an AI-assisted welding trainer that combined HD cameras, RGB-D sensors, and machine learning to assess welding performance and found that, in a controlled trial, trainees using the AI-enhanced system achieved significantly greater accuracy and faster skill acquisition than those taught through conventional methods or non-AI virtual reality environments. The study's rigorous experimental design strengthens its credibility within technical education research. Wahjusaputri et al. (2024) examined an AI-supported production line in which students actively participated. The study found notable improvement in students' technical competence, operational efficiency, and perceived industry readiness. This model demonstrates how integrating AI into authentic technical tasks can enhance both skill development and employability outcomes.

10. AI's Role in Transforming Education and Skills

In recent years, Artificial Intelligence integration into education and training has generated increasing interest, presenting promising opportunities for transforming Nigeria's learning systems and workforce development. The following highlights some potential contributions of AI in reshaping technical and vocational education in the country:

I. **Enhancing Personalised Learning:** AI-powered technologies have the potential to facilitate personalized learning by adjusting to students' individual needs, preferred learning styles, and pace. According to Popenici and Kerr (2017), intelligent tutoring systems enable the creation of customized learning pathways, providing learners with targeted support and guidance based on their strengths and areas requiring improvement.

II. **Connecting Education to Industry:** AI-enabled career guidance and job-matching systems can align education with industry needs (Abubakar et al., 2021). By analysing labour market trends and identifying emerging skill demands, these systems offer personalised recommendations that prepare graduates with industry-relevant competencies, thereby strengthening employability.

III. **Promoting Hands-on Training:** AI-driven simulations and virtual environments provide students with experiential learning opportunities in technical education (Adedoyin & Oyeniran, 2022). Through realistic, interactive scenarios, learners can safely practise vocational and industrial tasks such as automotive repairs, welding, or electrical installations to enhance their practical competence.

11. Conclusion

This study has examined the transformative roles of AI in industrial technical education, highlighting its capacity to foster innovation and enhance students' readiness for sustainable participation in the world of work. Evidence suggests that AI applications provide unique opportunities to enhance teaching, personalize learning, and better align training with industry demands. By creating more engaging, flexible, and practical learning environments, such technology has the potential to reduce unemployment rates, equip students with industry-relevant competences, and promote lifelong learning in line with Sustainable Development Goal 4.

Nevertheless, the integration of this intelligent tool in technical education is constrained by significant challenges. High implementation costs, inadequate infrastructure, insufficient digital literacy, and a shortage of AI experts hinder its widespread adoption. Equally concerning are ethical issues such as data privacy and the risk of overdependence on technology, which may undermine critical thinking and interpersonal skill development. Addressing these barriers requires deliberate collaboration between government, educators, industries, and policymakers. While the skeptics' concerns reflect valid systemic limitations, this paper takes the position that redefining technical education through Artificial Intelligence is both necessary and beneficial for employability and sustainability, provided that integration is strategic and supported by policy reforms. The argument rests on the premise that maintaining traditional methods in a technology-driven era will further widen the gap between Nigeria's labour force and global industry expectations. AI does not replace foundational reforms but strengthens them by making education more relevant, efficient, and responsive to labour market realities.

12. Recommendations

I. Government and stakeholders should prioritise investment in reliable electricity, high-speed internet, and modern workshop tools. Without stable infrastructure, the integration of artificial intelligence into technical education will remain superficial and widen existing inequalities.
II. Educators should receive regular training to use AI tools effectively.

III. Technical education curricula should be updated to include AI-related skills and competencies.
IV. Institutions should partner with industries to access AI technologies and align training with labour needs.
V. Policymakers should develop clear ethical and regulatory guidelines for AI use in technical education.

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