

Leveraging AI for Skills Development in Technical and Vocational Education

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ABSTRACT

Technical and vocational education and training (TVET) is central to Nigeria's quest for youth employment, industrialisation and economic diversification, yet the sector is constrained by obsolete equipment, shortages of skilled instructors, limited workshop practice and a widening gap between training and labour-market needs. At the same time, artificial intelligence (AI) is transforming both how skills are taught and which skills the world of work demands. This conceptual paper examines how AI can be leveraged for skills development in technical and vocational education, with particular reference to Nigeria. Drawing on Kolb's experiential learning theory and human capital theory, the paper clarifies the concepts of TVET, skills development and AI, and identifies key areas where AI can strengthen skills acquisition: intelligent tutoring and adaptive learning, AI-enhanced simulation and virtual workshops, competency-based assessment and feedback, learning analytics, labour-market intelligence for curriculum alignment, support for instructor productivity, and the teaching of AI-related skills as part of TVET content. The paper also examines challenges, including inadequate infrastructure, low digital competence among instructors, cost, curriculum rigidity, data privacy and the risk of widening inequalities. It argues that AI should complement, not replace, hands-on practice and the instructor's role. Recommendations include integrating AI literacy into TVET curricula, instructor capacity building, investment in AI-ready workshops, partnerships with industry, and a national framework for ethical AI use in TVET.

Keywords: artificial intelligence; technical and vocational education and training; skills development; simulation; Nigeria

Introduction

Nations develop through the skills of their people. Technical and vocational education and training (TVET) is the part of the education system most directly responsible for producing the craftsmen, technicians and technologists who build, operate and maintain the infrastructure of a modern economy. Nigeria's National Policy on Education recognises this, describing technical and vocational education as the aspect of education that leads to the acquisition of practical and applied skills as well as basic scientific knowledge (Federal Republic of Nigeria, 2013). With a large and growing youth population and persistent youth unemployment, the country's need for effective TVET has never been greater. Yet TVET in Nigeria faces long-standing problems. Workshops in many technical colleges, polytechnics and colleges of education (technical) are equipped with obsolete or non-functional machines. There are too few qualified instructors, particularly in emerging trades. Large classes limit each student's time on tools and equipment, and curricula are revised too slowly to keep pace with changes in industry. As a result, many graduates leave with certificates but without the competences employers seek. Artificial intelligence (AI) is relevant to TVET in two ways. First, AI is changing the world of work itself. It is automating some routine tasks, creating new tasks, and changing the skill content of many occupations, from automotive repair and electrical installation to agriculture and construction (Acemoglu & Restrepo, 2019; World Economic Forum, 2025). TVET must prepare learners for these changing jobs. Second, AI offers new tools for teaching and learning skills: intelligent tutors, adaptive learning platforms, AI-enhanced simulations, automated feedback and learning analytics (Holmes et al., 2019; Luckin et al., 2016). Used wisely, these tools could help TVET institutions overcome some of their resource constraints. The purpose of this paper is to examine how AI can be leveraged for skills development in technical and vocational education, with particular reference to Nigeria. Specifically, the paper (a) clarifies the key concepts, (b) presents a theoretical basis for AI-supported skills development, (c) identifies the main areas where AI can strengthen TVET, (d) discusses the challenges of adoption in the Nigerian context, and (e) proposes strategies for effective and responsible integration.

Conceptual Clarification

Technical and Vocational Education and Training TVET refers to education and training that prepares people for specific occupations or groups of occupations, combining practical skills, technical knowledge and work-related attitudes. In Nigeria, it is delivered in technical colleges, vocational enterprise institutions, polytechnics, monotechnics, colleges of education (technical) and universities of technology, as well as through apprenticeship and informal training. Billett

(2011) emphasises that vocational education serves several purposes at once: preparing individuals for work, sustaining

occupations and contributing to national economic goals. Its defining feature is learning by doing, through supervised practice in workshops, laboratories and workplaces.

Skills Development

Skills development is the process of acquiring and improving the abilities required to perform tasks competently. In TVET it covers three broad categories: • Technical skills: the occupation-specific abilities to use tools, machines, materials and procedures, such as welding, wiring, machining, garment construction or crop production. • Cognitive and digital skills: the ability to read technical drawings, diagnose faults, solve problems and use digital tools, including computer-aided design and diagnostic software. • Employability and entrepreneurial skills: communication, teamwork, safety awareness, work ethic and the ability to start and manage a small business. Skills development in TVET is typically competency-based: learners progress by demonstrating that they can perform defined tasks to a set standard, rather than by time spent in class.

Artificial Intelligence

Artificial intelligence refers to computer systems that perform tasks normally requiring human intelligence, such as recognising patterns, understanding language, making predictions and recommending actions (Luckin et al., 2016). Modern AI relies largely on machine learning, in which systems learn patterns from data. Generative AI, a recent branch, produces new text, images, code and other content in response to prompts (Kasneci et al., 2023).

Leveraging AI for Skills Development

In this paper, leveraging AI for skills development means the deliberate use of AI tools and systems to improve how TVET learners acquire, practise and demonstrate competences, together with the inclusion of AI-related knowledge and skills in TVET programmes so that graduates can work effectively in AI-influenced occupations. Both dimensions matter. A TVET system that uses AI to teach outdated skills, or that teaches about AI without using it to improve training, would capture only half the opportunity.

Theoretical Framework

Experiential Learning Theory

Kolb's (1984) experiential learning theory holds that learning is the process by which knowledge is created through the transformation of experience. Learning moves through a four-stage cycle: concrete experience (doing a task), reflective observation (thinking about what happened), abstract conceptualisation (forming principles from the experience) and active experimentation (applying those principles in new attempts). TVET is experiential by nature, since skills are learned by practising them.

The theory explains how AI can strengthen skills development without displacing practice. AI-enhanced simulations provide additional concrete experiences when real equipment is scarce or dangerous. AI feedback tools support reflective observation by pointing out exactly where a learner's performance fell short. Intelligent tutors and chatbots support abstract conceptualisation by explaining the principles behind a procedure in response to the learner's questions. Adaptive systems then set new tasks for active experimentation, at a suitable level of difficulty. In this way AI can increase the number and quality of trips around the learning cycle each learner makes.

Human Capital Theory

Human capital theory, associated with Becker (1964), views education and training as investments that raise individuals' productivity and earnings and, in aggregate, a nation's economic output. The theory justifies public and private investment in TVET as a driver of development. It also implies that the value of training depends on its relevance: skills that the labour market no longer needs yield low returns. As AI changes the skill content of jobs (Acemoglu & Restrepo, 2019), human capital theory points to the need for TVET to update what it teaches, so that the investment in learners remains productive. Together, the two theories frame the paper's argument: experiential learning theory explains how AI can improve the process of skills acquisition, while human capital theory explains why the content of TVET must evolve with AI.

Areas for Leveraging AI in TVET Skills Development

Intelligent Tutoring and Adaptive Learning

Intelligent tutoring systems guide learners through problems step by step, diagnose misconceptions and adjust tasks to each learner's level. A meta-analysis by Kulik and Fletcher (2016) found that such systems raised performance above conventional instruction in most of the studies reviewed. In TVET, they can teach the theory that underpins practical work, such as electrical circuit calculations, engineering drawing, materials science and fault-diagnosis logic. Generative AI chatbots, configured with course content, extend this support by answering learners' questions at any hour and in simple language (Kasneci et al., 2023). This is valuable where instructor-to-student ratios are high.

AI-Enhanced Simulation and Virtual Workshops

Simulation allows learners to practise procedures repeatedly without consuming materials, damaging equipment or risking injury. Virtual and augmented reality environments, increasingly combined with AI, can simulate welding, spray painting, engine diagnosis, electrical installation and machine operation. AI makes these simulations responsive: it tracks the learner's actions, detects errors such as incorrect welding angle or unsafe sequence, and adjusts difficulty. Radianti et al. (2020) found that immersive virtual reality is increasingly used for procedural and

practical skills training in higher education. For Nigerian institutions lacking modern machines, simulation can provide exposure to equipment that learners would otherwise never see before they reach the workplace. Simulation should prepare for, not replace, practice on real tools.

Competency-Based Assessment and Feedback

Assessing practical skills is labour-intensive. AI can support assessment through computer vision that analyses videos or images of learners' work, such as weld beads, tiling or garment seams, against quality standards; through automated scoring of theory tests; and through instant, specific feedback. This allows learners to attempt tasks more often and receive feedback each time, which is the core of competency-based training. Final certification decisions should remain with qualified assessors, with AI serving as an aid.

Learning Analytics

Learning analytics uses data from learners' interactions with digital systems to monitor progress, identify learners at risk of failing or dropping out, and inform teaching decisions (Holmes et al., 2019). In TVET, analytics can show which competences a class is struggling with, which learners need extra workshop time, and which teaching approaches are working, allowing scarce instructor time to be targeted where it is most needed.

Labour-Market Intelligence and Curriculum Alignment

AI can analyse large volumes of job advertisements, industry reports and employer surveys to identify which skills are in demand, which are emerging and which are declining. TVET regulators and institutions can use such intelligence to revise curricula more quickly and to advise learners on trade choices. The World Economic Forum (2025) reports rapid shifts in the skills employers expect, including technological literacy and analytical thinking, which underlines the value of continuous labour-market monitoring.

Support for Instructor Productivity

Generative AI can help TVET instructors prepare lesson notes, job sheets, safety checklists, assessment items and translated materials, freeing time for hands-on supervision. Brynjolfsson et al. (2025) found that access to a generative AI assistant raised the productivity of workers, with the largest gains among less experienced workers, suggesting similar potential for newly recruited instructors. Instructors must, however, check AI-generated content for technical accuracy and safety, since errors in a procedure can cause injury.

Teaching AI-Related Skills as TVET Content

AI is entering the trades themselves: diagnostic software in modern vehicles, smart meters and solar systems with automated monitoring, precision agriculture, predictive maintenance in factories, and AI-assisted design in construction and fashion. TVET graduates need the skills to work alongside these systems: operating and maintaining AI-enabled equipment, interpreting system outputs, collecting and handling data, and basic AI literacy, including awareness of AI's

limits and ethics (Ng et al., 2021; UNESCO, 2024a). Embedding these skills in existing trades, rather than treating AI as a separate subject, keeps training practical and relevant.

Challenges of Leveraging AI in Nigerian TVET Nigeria has shown policy interest in AI, most notably through the draft National Artificial Intelligence Strategy, which identifies talent development as a pillar of national AI readiness (National Information Technology Development Agency [NITDA], 2024). However, several obstacles stand between policy and practice in TVET institutions. Inadequate infrastructure. Erratic electricity supply, poor and costly internet connectivity, and shortages of computers and devices limit the use of any digital tool. AI-enhanced simulation, in particular, requires capable hardware that many institutions lack. Low digital and AI competence among instructors. Many TVET instructors were trained before digital tools became common and have had limited opportunities for retraining. Celik et al. (2022) identified teachers' limited technical knowledge as a recurring barrier to AI use in education. Instructors who are unfamiliar with AI cannot integrate it meaningfully into their teaching. Cost and sustainability. Licences for simulators, premium AI platforms and supporting hardware are expensive, and donor-funded pilots often lapse when funding ends. Institutions need sustainable financing models. Curriculum rigidity. TVET curricula are revised infrequently and through lengthy processes. AI-related content and AI-supported methods are therefore slow to enter official programmes, even where instructors are willing. Relevance of available tools. Most AI education tools are designed for other contexts and languages. They may not reflect Nigerian trades, equipment, standards or examples, which reduces their usefulness and learners' trust. Data privacy, accuracy and ethics. AI systems collect learner data and can produce inaccurate output. In technical training, an error in a procedure or safety instruction can cause injury. Clear rules on data protection, verification of content and accountability are needed (UNESCO, 2024b). Risk of widening inequality. If AI tools are available only to well-resourced institutions or to learners who own smartphones and can afford data, AI may widen gaps between urban and rural institutions, and between richer and poorer learners. Over-reliance and displacement of practice.

There is a risk that institutions treat simulations and AI tutors as substitutes for workshops and instructors, particularly where equipment is lacking. Skills such as welding or bricklaying cannot be fully acquired without physical practice, and AI must remain a complement.

Strategies for Effective Integration of AI in TVET Adopt a blended, practice-first model. AI should be positioned as a support to the experiential learning cycle, not a replacement for it. A practical model is: learners study theory and safety with an AI tutor, rehearse procedures in simulation, practise on real equipment under instructor supervision, and receive AI-assisted feedback on their work. This model uses scarce workshop time more efficiently, because learners arrive at the machine better prepared. Build instructor capacity first. No technology succeeds without competent instructors. Regular, hands-on training should cover AI tools for teaching and assessment, verification of AI-generated content, and the AI-related skills now entering each trade. Instructor training should be tied to recognition and career progression. Start with low-cost, high-impact tools. Institutions need not wait for expensive simulators. Smartphone-based AI tutors, free generative AI tools for preparing teaching materials, and simple analytics within existing learning management systems can be adopted quickly, while larger investments are planned. Invest in AI-ready workshops and infrastructure. Government and institutions, with support from interventions such as those of the Tertiary Education Trust Fund (TETFund), should provide solar-backed power, reliable internet and shared simulation laboratories. Shared regional centres can serve several institutions and reduce cost. Partner with industry. Employers, technology firms and technology hubs can supply up-to-date equipment, software, data on skill needs, internships and guest instructors. Partnerships also help ensure that AI-related content reflects how AI is actually used in Nigerian workplaces. Reform curricula for agility. TVET regulators should adopt faster, modular revision processes, informed by AI-based labour-market intelligence, and embed digital and AI skills within existing trades. Competency standards in national qualifications frameworks should be updated to include the use of AI-enabled tools. Localise AI tools. Developers, institutions and researchers should create or adapt AI tutors and simulations that use Nigerian trades, standards, examples and, where useful, local languages. This raises relevance and accessibility for learners. Establish an ethical framework. A national framework for AI in TVET should address learner data protection, safety verification of AI-generated procedures, accountability for assessment decisions, equitable access, and transparency about when AI is used (UNESCO, 2021). Promote equitable access. Device-loan schemes, offline-capable tools and institutional internet access can ensure that AI benefits reach rural institutions, women in technical trades, and learners with disabilities, rather than only the already advantaged.

Conclusion

AI presents technical and vocational education with both a challenge and an opportunity. The challenge is that AI is changing the skills that jobs require, so TVET that does not adapt will produce graduates for occupations that no longer exist in their old form. The opportunity is that AI offers tools that can make skills training more personalised, more frequent, safer and better aligned with the labour market, helping Nigerian institutions overcome shortages of equipment and instructors. Realising this opportunity depends on instructors who are competent with AI, infrastructure that can support it, curricula that embrace it, and policies that ensure it is used safely and fairly. Above all, AI must strengthen, not replace, the hands-on practice and expert guidance that remain the heart of TVET.

Recommendations

1. The National Board for Technical Education (NBTE) and the National Commission for

Colleges of Education (NCCE) should integrate AI literacy and AI-related trade skills into TVET curricula and update national occupational standards accordingly.

2. Government and TVET institutions, with TETFund support, should run continuous

capacity-building programmes for TVET instructors on using AI for teaching, assessment and workshop practice.

3. Government should invest in solar-backed power, internet connectivity and shared AI-

enhanced simulation centres serving clusters of TVET institutions.

4. TVET institutions should form partnerships with industry and technology hubs for

equipment, internships, labour-market data and co-developed training content.

5. NITDA, the NBTE and the NCCE should jointly develop a framework for the ethical and

safe use of AI in TVET, covering data protection, content verification, assessment and equitable access.

6. Researchers and developers should build and evaluate localised AI tutors and

simulations for priority Nigerian trades, and empirical studies should test their effect on learners' skill acquisition.

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