International Journal of Academic Multidisciplinary Research (IJAMR)
ISSN: 2643-9670
Vol. 9 Issue 12 December - 2025, Pages: 381-390

Leveraging Digital Skills And AI For Entrepreneurship Innovation In TVET: Pathway To Wealth Creation

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Abstract: *The swift evolution of digital technologies and artificial intelligence (AI) is radically transforming the global landscape of employment, business formation, and necessary competencies. Amidst these shifts, Technical and Vocational Education and Training (TVET) has become a vital mechanism for empowering individuals with practical, industry-aligned skills. These competencies are essential for driving entrepreneurial innovation and generating sustainable value. This article investigates the synergistic effects of embedding Fourth Industrial Revolution (4IR) tools specifically digital skills and AI into TVET frameworks. The analysis demonstrates how such integration bolsters entrepreneurial potential, sparks creativity, and fosters broader economic inclusivity. Furthermore, the study explores the ways in which proficiency in digital technologies enables TVET alumni to conceptualize novel products, services, and business models. These innovations address gaps in modern markets, particularly within technology-centric sectors and the informal economy. However, despite this promise, significant impediments remain. The research highlights systemic issues including poor technological infrastructure, a scarcity of digital resources, gaps in instructor preparedness, and disparities in access among different socio-economic demographics. These obstacles currently limit the effectiveness of TVET in a digital age. The paper asserts that without targeted policy changes and structural reforms, these barriers will erode the capacity of TVET to serve as an engine for wealth creation. In response, the study outlines a strategic roadmap for enhancing 4IR adoption within vocational training. Key recommendations include capital investment in connectivity and hardware, upskilling lecturers in emerging technologies, updating curricula to match 4IR demands, deepening ties with industry partners, and ensuring government backing for an inclusive digital transition. By framing digital skills and AI as essential drivers of entrepreneurial progress, this article adds to the conversation on how TVET can effectively drive employment, wealth generation, and socio-economic transformation in the modern era.*

Keywords: Digital Skills, Artificial Intelligence, Entrepreneurship Innovation, Technical and Vocational Education and Training (TVET), Fourth industrial revolution

Introduction

The swift digital transformation of the worldwide economy has fundamentally reshaped the essence of employment, production, and business growth, establishing technological proficiency as a critical requirement for economic participation. In this dynamic environment, Technical and Vocational Education and Training (TVET) serves as a strategic platform for providing individuals with the practical competencies necessary to meet current labor market demands. As noted by Seleke and Teis (2025), TVET specifically provides youth with tangible, job-oriented skills that bolster their employability prospects. In contrast to conventional academic tracks, TVET emphasizes skill-based learning, thereby guaranteeing that graduates are prepared for the workforce and capable of addressing the requirements of evolving sectors (Stanford, 2024; Suryati et al., 2024). While TVET has historically played a pivotal role in generating technicians, artisans, and mid-level workers essential for national development, the emergence of the Fourth Industrial Revolution (4IR) has altered the expectations for technical education. This shift necessitates moving beyond traditional skill sets to prioritize digital literacy, creativity, and competencies driven by innovation. The 4IR is characterized by the convergence of automation, artificial intelligence (AI), the Internet of Things (IoT), blockchain, robotics, and big data analytics (Voronkova et al., 2023). These technologies are reconfiguring established industries and birthing new economic sectors, thereby redefining the nature of work and employability.

In this modern technological paradigm, digital skills and artificial intelligence (AI) are increasingly recognized as primary drivers of entrepreneurial capacity and wealth generation. Digital skills—spanning from basic computer literacy to advanced proficiency in software applications, online communication, and data analytics—empower individuals to utilize technology for business development (Denysenko et al., 2024). As a transformative innovation, AI expands these possibilities by refining decision-making processes, streamlining routine tasks, optimizing production workflows, and offering predictive insights that foster business expansion (Mohammed and Madhumithaa, 2024). The convergence of these technologies not only broadens the scope of entrepreneurial prospects but also reduces entry barriers for aspiring entrepreneurs, particularly young people in developing nations. Consequently, the rising importance of digital transformation in educational and professional settings has amplified the need for

TVET institutions to reassess their roles within national innovation ecosystems (Harikirishanan, 2024). TVET centers are no longer limited to preparing learners for salaried employment; instead, they are increasingly being repositioned as incubators for creativity, technological experimentation, and enterprise development. By embedding digital skills and AI-based tools into their training curricula, TVET institutions can empower learners to conceptualize, design, and sustain innovative business ventures. This transition is especially vital in societies grappling with youth joblessness, unstable labor markets, and limited avenues for upward economic mobility.

Moreover, the value of incorporating digital skills and AI into TVET extends beyond personal empowerment to influence broader socio-economic progress. Entrepreneurship anchored in digital technologies fosters new markets, boosts productivity, and secures competitive advantages on both national and global scales. For developing economies, where traditional industries may be contracting or unable to accommodate the expanding youth demographic, digital entrepreneurship offers a feasible route to inclusive growth. Through access to digital tools, online marketplaces, AI-driven productivity applications, and affordable technological infrastructure, TVET graduates can engage significantly in both local and international value chains (Andreoni et al., 2021). However, realizing the potential of digital transformation within TVET systems requires intentional structural, pedagogical, and policy interventions. Successful integration demands curriculum modernization, the enhancement of instructor capabilities, investment in digital infrastructure, and robust partnerships between TVET institutions and technology-centric industries. Without such systemic reforms, the capacity of digital skills and AI to catalyze entrepreneurial innovation may remain unexploited. As the global community embraces Industry 4.0, it is essential to analyze the profound implications of 4.0 digital technologies on entrepreneurship education (EE) within Higher Education Institutions (HEIs). For instance, advancements in artificial intelligence (AI), big data, virtual reality (VR), cloud computing, and the Internet of Things (IoT) have fundamentally transformed how scholars interact, collaborate, and learn (Pinto and Leite, 2020; Akour and Alenezi, 2022). These technologies have disrupted conventional business models and generated new opportunities for entrepreneurial ventures (de Waal and Maritz, 2022). In light of these rapid developments, it is crucial to examine how entrepreneurship education programs can effectively adopt and apply Industry 4.0 digital technologies and AI. This will equip students with the relevant skills and competencies required to thrive in entrepreneurial innovation within the TVET sector, ultimately fostering opportunities for wealth creation.

THEORETICAL AND CONCEPTUAL FRAMEWORK

This section elucidates the theoretical perspectives that form the basis for analyzing the integration of 4IR in TVET and defines the key concepts relevant to the study.

Theoretical Perspectives

Human Capital Theory (HCT)

Human Capital Theory (HCT) asserts that investment in education and skills acquisition augments economic productivity and the potential for individual earnings (Afutu-Kotey et al., 2024; La, 2024; Mastromartino, 2024). This theory offers a compelling rationale for upskilling and reskilling youth through TVET to enhance their employability and economic contributions within the context of 4IR in South Africa. Carpenter et al. (2024) argue that, from a policy standpoint, HCT highlights the economic necessity of embedding 4IR into TVET. According to Awad (2025), nations that allocate resources to digital skills development are better equipped to compete in the global economy, mitigate unemployment, and stimulate technological innovation. We align with Badugela (2024) in observing that if investments in digital education are not equitably distributed, marginalized communities risk exclusion from 4IR-driven economic opportunities, thereby exacerbating the digital divide.

Systems Theory

As described by Leoni (2024), Systems Theory perceives institutions as interconnected systems where alterations in one component impact the entire structure. Regarding TVET, a systems approach acknowledges that the successful integration of 4IR is contingent upon the alignment of various elements:

- Education policy (encompassing government regulations and funding mechanisms).
- Industry partnerships (involving private sector engagement and skills demand).
- Institutional readiness (including infrastructure, curriculum design, and lecturer capacity) (Harney, 2024).

Recent studies indicate that a disjointed approach to adopting 4IR in TVET is unlikely to yield sustainable results. Conversely, a model driven by systems thinking ensures that the digital transformation of TVET is comprehensive, inclusive, and responsive to the needs of the labor market (Harney, 2024; Lehmann, 2024; Nolan and Owen, 2024).

Operational Definition of Terms

Digital Skills

In academic discourse, the notion of 'digital skills' is ubiquitous, characterized by a multiplicity of definitions. A foundational perspective often cited in subsequent literature is offered by Van Dijk (2006), who conceptualizes these skills as the prerequisite abilities users require to manipulate computer networks, retrieve and select information, and apply these resources to achieve personal objectives. Van Dijk's framework categorizes these capabilities into three distinct domains: technical operations, information navigation, and strategic usage.

More recent scholarship has expanded on this plurality. For instance, a text-mining analysis of 1,037 academic articles by Tinmaz et al. (2022) identified the most recurrent terms associated with digital skills, including ICT proficiency, information literacy, communication, collaboration, content creation, research, and decision-making. Further extending this taxonomy, Van Laar et al. (2017) delineate digital skills into technical proficiency, information management, communication, collaboration, creativity, critical thinking, and problem-solving. Howard (2023) draws a distinction between the 'soft' and 'hard' aspects of these competencies. The former encompasses interpersonal and cognitive abilities such as communication, decision-making, and creativity, while the latter involves technical aptitudes like software operation, coding, programming, and big data analytics. Ultimately, digital proficiency is stratified into four tiers: foundational (essential for lifelong learning), intermediate, specialized, and highly specialized.

Artificial Intelligence

Artificial Intelligence (AI) constitutes a branch of computer science dedicated to engineering software capable of mimicking human cognition and behavior to solve practical problems (Webber and Nilsson, 2014). Defining the capabilities of AI often involves the criterion of machine interaction, where a system communicates with a user via electronic devices without revealing its non-human identity—a binary judgment of intelligence (Jiang et al., 2022).

The utility of AI is driven by core technologies such as machine learning, natural language processing, computer vision, and robotics. These tools are deployed to navigate complex challenges, boost operational efficiency, and generate innovative solutions across various sectors (Rai, 2020; Marr, 2021). By leveraging vast datasets to produce accurate predictions and automate workflows, AI offers a promising mechanism for addressing systemic issues (Ndukwe, 2023; Adebayo, 2022). Consequently, AI technologies are fundamentally altering industries by optimizing accuracy, output, and efficiency (Haenlein and Kaplan, 2019).

Entrepreneurship and Innovation

Entrepreneurship is frequently cited as the primary engine of economic development, largely due to the introduction of "new combinations"—ranging from novel products and production methods to new markets and organizational structures (Thurik and Wennekers, 2004; Welter and Lasch, 2008; Wennekers and Thurik, 1999). A consensus exists among scholars that entrepreneurial activity is a prerequisite for economic growth, largely because of its contribution to job creation and the advancement of innovation (Davidsson et al., 2006).

Lakéus (2015) broadens this definition to include personal growth, proactivity, independence, and action-oriented behavior as core components of the entrepreneurial process. While entrepreneurs may be analyzed at an individual level, their impact resonates across organizational, economic, social, and institutional spheres (Veciana and Urbano, 2008).

Drucker (1985) famously posited that innovation is the specific tool of the entrepreneur—the act of endowing resources with new wealth-generating capacity. In line with this, evidence suggests that innovative firms generally outperform their non-innovative peers in financial and economic terms (Fernandes et al., 2013; Ferreira et al., 2010). Thus, innovation is not merely beneficial but essential for survival and success within a globalized economy.

Technical and Vocational Education and Training (TVET)

Technical and Vocational Education and Training (TVET) serves as a bridge between the educational system and the labor market. It comprises educational programs designed to instill practical skills, technical knowledge, and industry-specific competencies that enhance employability (Kebede et al., 2024; Meunmany, 2024; Varma and Malik, 2023). This is particularly critical in economies grappling with high youth unemployment, such as South Africa (Habiyaremye et al., 2022). In the era of the Fourth Industrial Revolution (4IR), the scope of TVET is shifting from traditional manual trades to digitally integrated vocational training. This evolution necessitates the adoption of smart classrooms, coding instruction, data analytics, AI-driven platforms, and online certification (Penniston, 2021). However, this transition is impeded by obstacles such as insufficient funding, a shortage of qualified instructors, and limited collaboration with industry partners (Els et al., 2022). Globally, TVET is recognized for providing the attitudes and skills required for effective workplace performance (Okoye and Okwelle, 2014). As defined by the Federal Republic

of Nigeria (FRN, 2004), TVET encompasses the study of technologies and the acquisition of practical knowledge related to various economic sectors.

Digital Skills and Private Sector Links: Leveraging TVET

TVET is increasingly regarded as a vital vehicle for digital transformation, responsible for cultivating the technical and digital competencies that drive productivity, innovation, and employment (Monga, 2017). Despite this potential, TVET suffers from low enrollment rates across the African continent, with an average of only 3% of individuals aged 15–24 participating (AUC, 2021). Provision is minimal at the lower secondary level (1.6%) and only marginally better at the upper secondary level (15%) (AUC, 2021). Furthermore, TVET is frequently treated as a substitute for general secondary education. This results in students lacking the foundational digital skills typically acquired through formal schooling (Fox and Signé, 2022). Beyond enrollment gaps, the system faces criticism regarding the quality and cost-effectiveness of its programs (Fox, 2019; Hamory Hicks, 2016). Broader systemic barriers include inadequate or obsolete infrastructure, a lack of competent educators, and insufficient professional development (Monga et al., 2019; Tikly et al., 2018). Additionally, underinvestment in technology and outdated curricula—often poorly aligned with labor market demands—further hinder progress (Haßler and Haseloff, 2022). Implementation is also complicated by unwieldy National Qualification Frameworks (NQFs) (Arias et al., 2019). Addressing these failures requires cross-sector collaboration to update curricula and strengthen industry ties. When TVET is strategically designed and aligned with labor market needs, it can yield significant economic returns over time, as observed in other global regions (Arias et al., 2019).

AI and Entrepreneurial Opportunities

The convergence of AI and innovation has fundamentally reshaped the entrepreneurial landscape. By utilizing massive datasets and advanced machine learning algorithms, AI provides a powerful mechanism for predicting trends and uncovering new business prospects (Corkburn *et al.,* 2018). This synergy promises to revolutionize traditional business models and drive substantial growth (Obschonka and Fisch, 2022).

As AI becomes more embedded in entrepreneurship, its capacity to detect patterns and insights beyond human scope facilitates the identification of market gaps and customer needs on an unprecedented scale (Nambisan et al., 2019). The potential of AI-enhanced approaches lies in their ability to synthesize disparate information, generate innovative ideas, and accelerate business development (Nambisan *et al.,* 2018). However, it is crucial to recognize the limits of AI and the enduring value of human ingenuity in opportunity recognition.

This impact extends into Higher Education (HE), where digital tools and big data are transforming pedagogical practices (Chalmers et al., 2021). Integrating AI into entrepreneurship education (EE) offers prospects for personalized learning, though it also necessitates careful consideration of ethical issues and potential biases in algorithmic decision-making (Mei and Symaco, 2022). Ultimately, the fusion of AI and entrepreneurship leverages big data not only to predict market shifts but to generate the transformative insights necessary for wealth creation (Lévesque *et al.,* 2022).

Challenges

Although the integration of Artificial Intelligence (AI) and digital proficiencies offers a transformative pathway for wealth generation within the Technical and Vocational Education and Training (TVET) sector, significant obstacles continue to obstruct its smooth adoption. These barriers arise from issues such as inadequate physical infrastructure, a lack of preparedness among instructors, a disconnect between policy frameworks and market requirements, and insufficient partnerships between educational institutions and the commercial sector (Mesuwini, 2024). Failure to adequately resolve these issues means that the potential for AI-driven TVET to foster economic growth might remain inaccessible to a large portion of the population. Consequently, this would exacerbate current societal disparities and weaken the overall impact of skills development initiatives.

Infrastructural Deficits and the Digital Divide in TVET Institutions

Shortcomings in physical infrastructure prevent learners from participating in technology-enhanced learning, which is essential for acquiring competencies in digital literacy, computing, and technical fields such as robotics, AI, and cloud computing. Furthermore, the gap in digital resources between colleges in urban centers and those in rural areas creates unequal opportunities for skill acquisition, putting students from financially disadvantaged backgrounds at a distinct disadvantage regarding exposure to cutting-edge technological applications (Mbambo and du Plessis, 2025). The financial burden of purchasing and sustaining digital infrastructure poses a significant challenge for TVET colleges (Pinto et al., 2025). Establishing smart classrooms, simulation laboratories, and online learning platforms demands substantial capital investment in hardware, software, and broadband services—a burden that many institutions struggle to bear.

Instructor Preparedness and Gaps in Training

Denhere and Moloi (2021) argue that the successful incorporation of Fourth Industrial Revolution (4IR) technologies into TVET is heavily contingent upon the readiness and competence of the teaching staff. However, a significant number of TVET lecturers lack the essential digital skills, pedagogical knowledge, and industry exposure required to effectively teach technology-driven curricula. According to Mbatha (2024), since many TVET instructors were educated in traditional vocational disciplines, their

understanding of emerging digital technologies is often limited. This deficit in expertise hampers their ability to design and deliver innovative learning experiences that are aligned with 4IR advancements. Furthermore, opportunities for professional development within the TVET teaching force remain insufficient (Amoo, 2021; Makgato, 2022). Numerous training modules prioritize theoretical knowledge over practical application, leaving educators ill-equipped to navigate digital learning environments, integrate new technologies into their instruction, or facilitate project-based learning that mimics real-world industry challenges. The absence of structured industry immersion programs further prevents lecturers from staying current with technological trends and best practices (Majola, 2024). To bridge these gaps, Makgato (2022) suggests that comprehensive capacity-building initiatives are required to reskill and upskill TVET instructors.

Disconnect Between Policy, Curriculum, and Market Requirements

The rapid evolution of technology implies that TVET curricula often become obsolete quickly, failing to incorporate new competencies such as data analytics, automation, and digital problem-solving. As a result, graduates frequently lack the practical skills needed in modern work environments, leading to elevated unemployment rates despite the rising demand for skilled workers in 4IR sectors (Bodibe, 2023). Additionally, the policy frameworks governing TVET systems often require years to revise, making it difficult for institutions to adapt swiftly to industry transformations. Tekle et al. (2024) observe that in many countries, TVET curriculum development is a bureaucratic process where new training programs require extensive regulatory approval prior to implementation. This procedural lag hinders curriculum innovation, preventing students from acquiring the latest skills in digital manufacturing, smart logistics, and AI-driven services. Van der Hijden and Martin (2023) also advise that the lack of national qualification frameworks accommodating micro-credentials and stackable learning pathways further restricts the career mobility of TVET graduates.

Restricted Cooperation Between Industry and TVET for Digital Skill Acquisition

A major hurdle in transforming TVET through the 4IR is the limited collaboration between colleges and industries in the design and delivery of technology-based training programs (Legg-Jack and Ndebele, 2022). Chanda (2023) notes that while businesses lead the way in technological advancements, TVET colleges frequently operate in isolation, resulting in training approaches that do not align with actual workplace demands. Many TVET programs fail to provide students with practical experience in smart factories, AI-driven logistics, or cloud-based service environments because formal linkages with the industry remain weak (Lukhele and Laseinde, 2024). Consequently, graduates enter the labor market with theoretical knowledge but limited practical exposure, rendering them less competitive in high-tech employment sectors. Employers often perceive TVET alumni as underprepared for digital workplaces, leading to a reluctance to hire them for technology-intensive roles (Papier, 2021).

STRATEGIC RECOMMENDATIONS

To ensure that TVET colleges can effectively adapt to the demands of the 4IR, targeted policy interventions and strategic initiatives must be implemented (Kana and Letaba, 2024). Addressing the infrastructure gap, enhancing lecturer capacity, transforming curricula, fostering industry partnerships, and enacting policy reforms will equip TVET graduates with future-ready skills that contribute to wealth creation. The following recommendations provide a roadmap for improving the digital preparedness, employability, and sustainability of TVET in the digital era.

Investment in Digital Infrastructure and Connectivity

One of the most critical challenges in embedding 4IR technologies into TVET is the uneven access to digital infrastructure and internet connectivity, particularly within rural and under-resourced institutions (Legg-Jack and Ndebele, 2022; Tondi, 2023). Without modern learning environments, digital laboratories, and high-speed internet, students lack exposure to innovative technologies, which limits their ability to develop critical digital competencies. To bridge this divide, investments by both the government and the private sector in TVET infrastructure must prioritize:

- **Broadening broadband access:** Ensuring reliable internet connectivity across all TVET colleges to enable access to cloud-based learning platforms, online simulations, and virtual collaboration tools.
- **Modernizing digital laboratories:** Equipping labs with AI-driven software, Internet of Things (IoT) devices, automation tools, and industry-standard equipment to enhance experiential learning.

Educating TVET Lecturers on 4IR Technologies

Lecturers play a central role in developing the technological competencies of students. However, many lack the digital skills necessary to effectively teach 4IR-relevant content, as their initial professional training often predates the emergence of automation, artificial intelligence, and digital fabrication (Els et al., 2022). To build lecturer capacity, national training programs should focus on:

- **Continuous Professional Development (CPD):** Implementing programs to train lecturers in emerging fields such as cybersecurity, robotics, cloud computing, and augmented reality.
- **Blended learning pedagogical training:** Equipping lecturers with the skills to integrate digital tools, AI-driven assessments, and e-learning platforms into their teaching methodologies.

Synchronizing TVET Courses with 4IR Competencies

The discrepancy between traditional TVET curricula and the skills demanded by 4IR industries is a primary factor contributing to graduate unemployment and skill shortages. To ensure students are work-ready, there is an urgent need to modernize curricula by integrating digital literacy, automation, and data-driven problem-solving skills into vocational training (Sey and Mudongo, 2021). Key curriculum reforms should include:

- **Embedding digital skills training:** Incorporating fundamental to advanced competencies in AI, IoT, blockchain, and digital manufacturing across all TVET disciplines.
- **Introducing interdisciplinary learning:** Combining technical training with soft skills such as critical thinking, adaptability, and digital collaboration to enhance overall employability.

Boosting Partnerships Between Industry and TVET

Vuthela and Ngumbela (2024) highlight that a major limitation of current TVET training is the students' lack of direct industry exposure. Many TV graduates struggle to transition into employment because they lack practical experience with digital work environments, smart factories, and automation-driven industries (Mayombe, 2024a). Strengthening collaboration between TVET and industry is vital for bridging the gap between education and employment. Key strategies to enhance work-based learning in digital sectors include:

- **Expanding apprenticeship and internship programs:** Increasing opportunities in AI-driven industries, software engineering firms, renewable energy sectors, and advanced manufacturing plants.
- **Establishing industry-aligned innovation hubs:** Creating hubs within TVET colleges where companies provide students with hands-on experience in digital prototyping, programming, and automation.

State Support for Lasting and Inclusive 4IR Uptake

The sustainable adoption of 4IR technologies in TVET requires robust policy frameworks that promote digital inclusivity, long-term investments, and regulatory alignment with labor market demands (Mbaluka and Munyifwa; Mtotywa et al., 2024). Governments must proactively shape TVET systems to support technological adaptation and ensure equitable access to skills training (Majola, 2024). Key policy interventions include:

- **Developing national digital skills strategies:** Outlining clear 4IR competency benchmarks and learning pathways for TVET colleges.
- **Providing financial incentives:** Offering grants, subsidies, and tax breaks to TVET colleges and companies that invest in digital training programs, e-learning infrastructure, and smart technologies.

CONCLUSION

This discussion highlights the pivotal importance of technological proficiency and machine learning in transforming Technical and Vocational Education and Training (TVET) to serve as an engine for business ingenuity and enduring prosperity. As global economic frameworks increasingly pivot toward information-centric systems, TVET entities are tasked with a mandate that extends beyond producing technically skilled workers. Instead, they must cultivate graduates who are adaptable, innovative, and capable of generating value within rapidly evolving employment sectors. By embedding AI tools and digital literacy into the curriculum, educational institutions can strategically empower learners to recognize market gaps, devise creative solutions, and convert their technical know-how into sustainable commercial enterprises. Nevertheless, achieving this vision is contingent upon the preparedness of TVET infrastructures to navigate systemic and resource-based obstacles. It is imperative to channel resources into upgrading technology, providing ongoing training for educators, fostering corporate alliances, and establishing equitable policies. These measures are crucial for ensuring that trainees acquire competencies that remain relevant in the future. In the absence of such organized and intentional efforts, the advantages of modernizing TVET through technology will likely be fragmented, thereby restricting its potential to drive broad-based economic development.

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