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# Technology Integration in TVET Education in Africa: A Scoping Review with Evidence Concentrated in Southern Africa

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**Abstract:** Digital transformation has significantly reshaped teaching and learning practices in higher education over the past two decades, particularly within the contexts of Technical and Vocational Education and Training (TVET). Despite this shift, there remains a paucity of comprehensive reviews that synthesise the integration of digital technologies in TVET institutions, along with the associated benefits and challenges. This study seeks to address this gap by conducting a scoping review of literature published between 2015 and 2025, guided by the PRISMA-ScR framework. Data were sourced from the Web of Science and Scopus databases. The initial search yielded 2046 records, which were subsequently screened using predefined inclusion and exclusion criteria, resulting in a final sample of 30 studies. The findings reveal that technology integration in African TVET institutions is characterised by six key themes: technology-enabled pedagogies, lecturer capability and readiness, institutional governance, digital infrastructure and the digital divide, emerging technologies, and learner outcomes and inclusion. The review highlights that digital technologies enhance student engagement, flexibility, and skills development, particularly through e-learning, blended learning, and immersive tools. However, these benefits are constrained by challenges such as inadequate infrastructure, limited digital literacy, and insufficient institutional support. Rooted in the Unified Theory of Acceptance and Use of Technology (UTAUT) and a socio-technical approach, the study explores technology integration, benefits, challenges, and enablers in TVET. The study recommends a multi-level approach to digital transformation, focusing on infrastructure, lecturer training, and inclusive policies to support the sustainable integration of technology in TVET.

***Keywords:*** TVET, technology integration, education, digital transformation, scoping review.

## 1. Introduction

Digital transformation represents a global phenomenon that is reshaping the education sector through the integration of digital and foundational technologies into existing systems, thereby optimising organisational processes and outcomes (Sheikh & Nath, 2026). Within the educational context, digital transformation not only redefines teaching and learning practices but also necessitates the development of new digital competencies among both educators and learners (Vial, 2021; Samuels & Singh, 2025). Instead of merely focusing on incremental changes spurred by the Fourth Industrial Revolution (4IR), digital transformation fundamentally alters curriculum development, assessment methods, and workforce readiness, rendering education systems vital for participation in the digital-era economy (Okunlola & Naicker, 2025; Tjahjono et al., 2025). Concurrently, the rapid pace of digital innovation is exposing significant gaps, particularly in the assessment of learning and its alignment with evolving technological environments (Pakala & Guniganti, 2025; Olagunju, 2026). Atamuratov and Xushvaqtov (2025) concur that digital transformation is influencing education on a global scale. The implications of this transformation are especially pronounced for Technical and Vocational Education and Training (TVET), where curricula

must swiftly adapt to meet industry demands and equip graduates with pertinent digital and employability skills (Jere et al., 2022). Cros et al. (2022) indicate that there is a limited understanding of how digital transformation is being integrated into TVET systems within the African context, particularly concerning the alignment of practices and skills, underscoring a critical gap that this study aims to address.

This study seeks to tackle the absence of comprehensive evidence regarding the integration of digital technology in TVET institutions, particularly in Africa, and examines the associated benefits and challenges. It reviews the literature on digital transformation in TVET to identify trends, benefits, challenges, and implications for skills development, institutional readiness, and inclusive education. To address the problem of the study, the following research questions were answered:

- What types of digital technologies are currently used in TVET institutions across Africa to improve teaching and learning?
- Which African countries contribute significantly to research on technology integration in TVET education?
- What institutional and pedagogical challenges influence the adoption and effective use of digital technologies in TVET education?
- What emerging opportunities exist for advancing digital transformation in TVET education across Africa?

The study contributes to current knowledge by synthesising research from 2015 to 2025, with a focus on Africa, highlighting pertinent themes and gaps, and offering evidence-based recommendations for strategic, inclusive, and sustainable digital change. The paper is organised into several sections: a literature review on digital transformation, methodology encompassing a scoping review and PRISMA-ScR, thematic findings, discussion, and a conclusion featuring recommendations, policy implications, and avenues for future research.

## 2. Literature Review

Technology integration has become increasingly important within Technical and Vocational Education and Training (TVET) as institutions respond to changing pedagogical practices, digitalisation, and evolving skills requirements. Within African TVET contexts, digital technologies offer opportunities to enhance teaching and learning, expand access to educational resources, and strengthen the alignment between vocational training and contemporary workplace practices. However, the integration of technology extends beyond the availability or adoption of digital tools and is influenced by lecturer capabilities, institutional readiness, infrastructure, governance, and the broader socio-economic environment. Understanding these interconnected dimensions is particularly important in African contexts, where differences in institutional capacity and access to digital resources may shape the extent and effectiveness of technology integration. This section, therefore, reviews the literature underpinning technology integration in TVET education, with particular attention to digital teaching and learning practices, enabling and constraining factors, and the theoretical perspectives used to understand technology adoption and integration within vocational education environments.

### 2.1 The importance of TVET in skills development

TVET institutions play a crucial role in shaping education systems by developing practical, industry-relevant skills for modern economies (Njengele et al., 2024). TVET is widely recognised as a driver of socio-economic development, particularly in addressing skills shortages and reducing unemployment (Makgato & Afeti, 2020; Bano, 2026). Although there is a general consensus on the importance of TVET development, scholars differ in their assessments of how effectively TVET systems translate this mandate into tangible employment and productivity outcomes. For instance, Asad et al. (2023) emphasise the potential of TVET to enhance economic productivity through

effective policies and efficient training systems, whereas Ntetha and Taole (2025) highlight persistent structural inequalities in the African context, such as unequal access, funding gaps, and weak institutional capacity that constrain this potential. Similarly, TVET is often associated with improved employability, self-employment, and socio-economic progress (Selane & Odeku, 2024; Rajamanickam et al., 2024). This optimistic view is complicated by concerns about the relevance and quality of training amid rapidly changing labour market demands. The responsiveness of TVET programmes to industry varies, highlighting gaps in curriculum alignment and implementation.

These challenges are intensified by the demands of digital transformation and the Fourth Industrial Revolution (4IR), which require both foundational and advanced digital skills. Efforts are underway to integrate 4IR competencies into TVET programmes, incorporating work-based learning to prepare graduates for technology-driven workplaces (Mazlan et al., 2025). However, a significant tension persists: policies require digitally ready graduates, yet many TVET institutions, particularly in developing regions, struggle with inadequate digital infrastructure, limited lecturer preparedness, and insufficient institutional support. Consequently, TVET's role is evolving amid digital transformation, moving from basic skills training to include digital literacy, innovation, and adaptability. This highlights the importance of gaining a thorough, evidence-based understanding of how digital technologies are being incorporated into TVET systems and whether such integration genuinely addresses current issues or creates new inequalities.

## 2.2 Technology integration in TVET education

Digital and capability learning are becoming increasingly crucial in today's technology-driven educational environment to promote digital learning. Despite many researchers primarily focusing on higher education, TVET institutions are transitioning from traditional to digital methods to improve knowledge, skills, and competencies (Palapa et al., 2026). According to Mohamad et al. (2024), technology in TVET institutions is increasingly attracting educators who wish to enhance learning outcomes. Technological methods such as online learning platforms, simulations, and digital tools have been integrated into TVET to support flexible learning and prepare students for 21st-century industries. Goff (2025) further demonstrates that modern technologies, such as virtual simulations, augmented reality, and AI platforms, are revolutionising education by creating a safe environment for educators to practise teaching strategies. Palapa et al. (2026) highlight that integrating technology into education enhances the digital abilities of both students and educators, improves performance, and increases engagement in TVET institutions. Raphael and Simon (2025) emphasise the necessity for TVET institutions to enhance their infrastructure and training to effectively implement digital teaching methods.

## 2.3 Challenges in digital transformation of TVET

TVET institutions are struggling to integrate technology and industry-relevant skills, leaving employees and graduates potentially unprepared for modern workforce demands (Vitalocca et al., 2026). According to Lutaaya et al. (2023), factors such as insufficient lecturer training, poor infrastructure, weak support, inadequate funding, fragmented curricula, and limited stakeholder collaboration hinder technology integration in TVET. For example, a study by Aina and Ogegbo (2022) found that educators at a TVET college face a lack of technology support, connectivity, training, a conducive environment, and infrastructure, as well as poor policies that hinder the adoption of virtual and sustainable learning. These issues have significantly impeded the progress of digital transformation in TVET, as educators continue to struggle to equip students with the digital and employable skills needed for relevant industries (Mtshali & Ramaligela, 2020). There is a perception that TVET colleges are not fully integrated with technology, as inadequate digital literacy and a lack of access to digital infrastructure continue to hinder the development of competence in TVET (Legg-Jack & Ndebele, 2023). Areba et al. (2024) further argue that despite significant changes

and increased digitisation in higher education, TVET colleges still face challenges in aligning their structures with the rapidly changing labour market.

Online learning in higher education has been extensively studied, particularly the use of information and communication technologies (ICTs) to expand access (Legg-Jack & Ndebele, 2023). However, less attention has been given to TVET institutions, which are regarded as under-resourced and lacking adequate access to online learning (Moloja & Ruhode, 2020). According to Zwane and Mudaua (2023), TVETs are facing challenges with open-distance e-learning and engaging with technology. Although TVET institutions are receiving research attention, few studies have focused on integrating technology into practical subjects that prepare employees and graduates for workplace readiness (Winberg & Hollis-Turner, 2021). Makgato and Afeti (2020) emphasise TVET's role in preparing students for industry, but there is limited research on effectively integrating technology into TVET to enhance digital skills, employability, and adaptability to changing labour markets. Moloja and Ruhode (2020) found that TVET colleges use cloud computing, but research mainly focuses on issues like data security, internet access, and infrastructure, with little attention to broader technology integration. Therefore, this study aimed to review how TVET institutions integrate digital technologies, highlighting emerging practices, challenges, and opportunities to prepare graduates through digital transformation.

## 3. Theoretical Framework

This study is grounded in the Unified Theory of Acceptance and Use of Technology (UTAUT), which offers a robust framework for understanding the factors that influence the adoption of digital technologies within educational contexts. It serves as the primary analytical framework that guides the interpretation of the findings (Venkatesh et al., 2003; Venkatesh et al., 2012). Specifically, the study utilises UTAUT to map the empirical themes into core constructs, where performance expectancy informs lecturers' perceived pedagogical value of digital tools; effort expectancy relates to ease of use and digital competence; social influence encapsulates peer and institutional expectations; and facilitating conditions reflect infrastructure, training, and institutional support. These constructs are employed to structure the analysis and discussion of the six themes, ensuring a systematic interpretation of lecturers' readiness and technology integration in TVET environments.

Given the complexity of digital transformation in African TVET institutions, the study adopts a socio-technical systems perspective alongside UTAUT as a complementary lens, situated within a broader systems framework (Baxter & Sommerville, 2011; Trist, 1981). While UTAUT elucidates behaviours, the socio-technical view highlights how technological, human, and organisational elements interact to influence these behaviours, particularly in resource-limited settings where infrastructure, policies, and socio-economic factors intersect with adoption decisions. The integration of the two frameworks is deliberate: UTAUT provides a structured, theory-driven basis for analysing adoption determinants, while the socio-technical systems perspective extends the analysis to account for broader systemic and contextual dynamics that UTAUT alone cannot fully encompass. This integration facilitates a more comprehensive analysis that transcends technology adoption to consider the broader pedagogical, institutional, and socio-economic dynamics shaping digital integration.

## 4. Methodology

This study employed a scoping review methodology in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews (PRISMA-ScR) guidelines (Tricco et al., 2018). Scoping reviews are particularly valuable for mapping the breadth and depth of existing knowledge within a field, identifying key concepts, and highlighting gaps that may inform future research and decision-making processes (Arksey & O'Malley, 2005; Levac, Colquhoun & O'Brien, 2010). In this context, the scoping review approach was deemed appropriate, as the study

aimed to examine the extent of existing knowledge regarding the integration of technology into teaching and learning within TVET institutions in the African context, while also identifying existing gaps in the literature. Figure 1 depicts the initial PRISMA-ScR search, which yielded 1,550 studies from Web of Science and 496 from Scopus, of which 293 were duplicates.

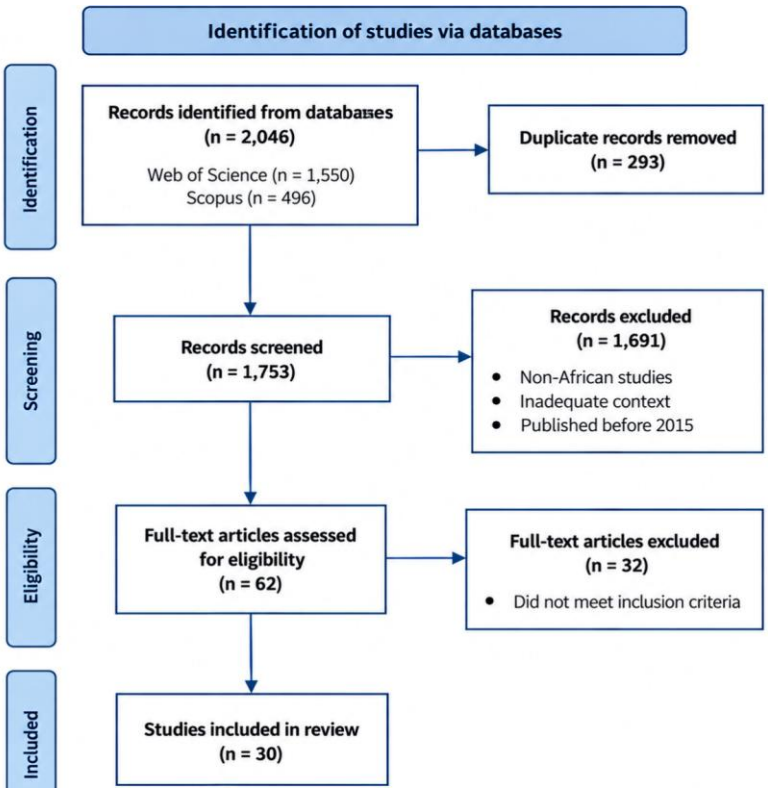


***Figure 1:*** *PRISMA-ScR studies selection process*

## 4.1 Identification of relevant studies

To address the research objective, a comprehensive literature search was conducted across four major academic databases, namely Web of Science, ScienceDirect, Scopus, and Africa Journals Online. The search encompassed studies published between 2015 and 2025 to capture recent developments and trends in technology integration within TVET institutions. A structured and systematic search strategy was developed to ensure precision and consistency in the retrieval of relevant studies. The search string incorporated a combination of keywords and Boolean operators aligned with the study's focus. The primary search terms included "TVET" OR "technical vocational education" OR "vocational education" combined with "digital technology" OR "ICT" OR "educational technology" OR "e-learning" OR "digital learning," and were further refined using "skills" OR "training" OR "teaching" OR "learning." These keywords were adapted as necessary to align with the indexing requirements and functionalities of each database, thereby enhancing the comprehensiveness of the search process. To ensure relevance and consistency, only studies published in English were included in the review. Furthermore, the review was limited to studies conducted within the African context or those explicitly focusing on TVET institutions in Africa.

## 4.2 Eligibility criteria

A set of inclusion and exclusion criteria was established to guide the selection of studies. The inclusion criteria concentrated on studies that provided empirical or conceptual evidence regarding the integration of technology within TVET institutions in Africa. Specifically, studies were included

if they reported on the use or adoption of digital technologies, such as information and communication technologies, e-learning platforms, or other forms of educational technology, within TVET contexts. Furthermore, studies that examined the benefits associated with technology integration, as well as those that highlighted challenges related to its implementation in teaching and learning, were deemed eligible. Conversely, studies were excluded if they focused on technology adoption in TVET contexts outside of Africa, or if they addressed educational technologies that were not pertinent to TVET institutions. Studies published prior to 2015 were also excluded to ensure that the review captured contemporary developments (i.e. 2015–2025). Additionally, articles that did not provide sufficient contextual detail regarding technology integration within African TVET institutions were omitted from the review.

### 4.3 Charting of data

Following the identification of relevant studies, the extracted records were imported into the Zotero reference management system to facilitate organisation and screening. A data extraction framework was developed to systematically capture key information from each study. The variables extracted included the study title, authors, research aim, abstract, full text, and the geographical context in which the study was conducted. The screening process was conducted collaboratively by two researchers to enhance the reliability and rigour of the review. Each study was assessed against the predefined eligibility criteria, and discrepancies were resolved through discussion and consensus. This process ensured that only studies meeting the inclusion criteria were retained for the final review and analysis.

### 4.4 Thematic analysis of included studies

Following the screening of the final thirty studies, a thematic analysis was conducted to identify recurring patterns across the included literature. The analysis was guided by the logic commonly employed in scoping reviews, wherein extracted evidence is not statistically pooled but rather synthesised narratively to map dominant trends, issues, and knowledge gaps. In this study, thematic analysis was employed due to the methodological diversity of the included evidence, which encompassed various contexts, technologies, and educational applications across TVET institutions in Africa (Braun & Clarke, 2006). The analysis followed an inductive and iterative process. Initially, the titles, abstracts, findings, and bibliographic details of the included studies were read repeatedly to achieve familiarity with the dataset. During this stage, preliminary notes were made on recurring themes such as e-learning adoption, lecturer readiness, infrastructure constraints, digital literacy, virtual learning, and governance issues. Secondly, initial codes were generated by grouping similar ideas and issues that appeared across the abstracts and full texts. These codes represented recurrent concepts rather than isolated findings. Examples of initial codes included technology-enabled teaching, lecturer competence, the digital divide, institutional support, and emerging technologies.

Thirdly, related codes were compared, merged, and organised into broader candidate themes. This step involved examining conceptual overlap across studies and determining whether the codes reflected coherent patterns relevant to the review objective. During the title and abstract screening stage, these themes served as provisional analytical categories that guided the subsequent full-text review rather than constituting the final thematic structure. Following the retrieval and charting of the full-text articles, the candidate themes were systematically re-examined against the complete dataset to verify their conceptual coherence, refine their boundaries, and ensure that they accurately represented the evidence presented in the included studies. Where necessary, themes were merged, renamed, redefined, or discarded based on insights obtained from the full-text analysis. Consequently, the final themes reported in this review emerged from the comprehensive analysis of the full-text articles rather than from the titles and abstracts alone.

The thematic analysis was guided by the six-phase framework proposed by Braun and Clarke (2006), which includes familiarisation with the data, generation of initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the final report. Consistent with this approach, the full-text articles were analysed iteratively to ensure that each theme demonstrated internal coherence, was clearly distinguishable from the others, and reflected meaningful patterns across the evidence base. In the context of this scoping review, the purpose of the thematic analysis was not to establish causal relationships but to map the dominant areas in which technology is integrated within TVET education in Africa, identify recurring challenges and opportunities, and highlight gaps requiring further investigation. Although the initial coding framework was informed by the title and abstract screening process, the themes reported in the final synthesis were validated and refined through full-text charting and narrative synthesis, thereby strengthening the rigour and trustworthiness of the review.

### 4.5 Bibliometric mapping and visualisation

In addition to the descriptive and thematic synthesis, a bibliometric analysis was conducted to provide a visual representation of the research landscape within the included studies. Bibliometric mapping was performed using VOSviewer (version 1.6.21), a software package widely employed for constructing and visualising bibliometric networks. The analysis was based on the final dataset of studies included in the scoping review following the PRISMA-ScR screening process. Two bibliometric analyses were undertaken. First, a keyword co-occurrence analysis was conducted using the author keywords and indexed keywords extracted from the included studies to identify the dominant research themes and conceptual relationships within the literature. A minimum occurrence threshold of two keyword occurrences was applied to enhance the clarity and interpretability of the network visualisation. Second, a country distribution analysis was performed to ascertain the geographical distribution of the included studies. Country attribution was based on the African country or countries in which each study was conducted, as reported in the full text of the articles, rather than the institutional affiliation of the authors. The bibliometric analysis complemented the thematic synthesis by providing an overview of the intellectual structure of the literature and highlighting geographical patterns in technology integration research within African TVET education.

### 4.6 Characteristics of the studies included

The characteristics and key details of the studies included for review are presented in Table 1.

***Table 1:*** *Summary of included studies on technology integration in African TVET education*

| No. | Study details | Focus and aim | Technology and key findings |
|---|---|---|---|
| 1 | **Authors:** Muinda et al. (2025)<br>**Country:** Uganda | **Study focus:** A Digitisation Model for Ugandan TVET Institutions<br>**Aim:** To develop a framework for improving digitisation project implementation in TVET institutions | **Technology:** Digitisation systems<br>**Key findings:** Process quality and communication significantly improve digitisation outcomes; monitoring mediates effectiveness; governance issues affect success |
| 2 | **Authors:** Makome et al. (2024)<br>**Country:** South Africa | **Study focus:** Framework for M-Learning in TVET<br>**Aim:** To develop a model for adopting mobile learning in TVET colleges | **Technology:** M-learning<br>**Key findings:** Awareness exists but usage is low; barriers include data costs and connectivity; structured frameworks needed for adoption |

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| 3 | **Authors:** Gumbo (2018)<br>**Country:** South Africa | **Study focus:** Misunderstanding of Technology Education<br>**Aim:** To explore factors contributing to misunderstanding of technology education | **Technology:** EdTech (Conceptual technology)<br>**Key findings:** Misconceptions about technology education limit effective implementation and curriculum alignment |
| 4 | **Authors:** Nwagwu (2023)<br>**Country:** Nigeria | **Study focus:** ICT Adoption in Vocational Colleges<br>**Aim:** To examine ICT adoption among teachers in vocational colleges | **Technology:** ICT tools<br>**Key findings:** ICT availability exists but accessibility is limited; self-efficacy influences adoption |
| 5 | **Authors:** Kamal Eldeen et al. (2023)<br>**Country:** Egypt | **Study focus:** Flipped Classroom in Vocational Education<br>**Aim:** To evaluate flipped classroom learning on student performance using data mining tools | **Technology:** LMS, data mining, flipped classroom<br>**Key findings:** Flipped learning improves student performance; LMS data predicts outcomes |
| 6 | **Authors:** Omeh et al. (2025)<br>**Country:** Nigeria | **Study focus:** AI in TVET Education<br>**Aim:** To examine adoption of AI in TVET and related ethical considerations | **Technology:** AI<br>**Key findings:** AI improves learning outcomes and engagement but requires ethical frameworks and policy support |
| 7 | **Authors:** Raban & Mayisela (2022)<br>**Country:** South Africa | **Study focus:** Blended Learning in TVET<br>**Aim:** To examine blended learning as an inclusive teaching approach | **Technology:** Blended learning<br>**Key findings:** Enhances access and inclusion but challenges remain in addressing inequalities |
| 8 | **Authors:** Ndjama (2025)<br>**Country:** South Africa | **Study focus:** Digital Divide in Vocational Schools<br>**Aim:** To explore digital divide challenges in vocational education | **Technology:** ICT<br>**Key findings:** Four types of digital divide identified; collaboration needed across stakeholders |
| 9 | **Authors:** Bessong et al. (2024)<br>**Country:** Nigeria | **Study focus:** Digital Literacy & Civic Engagement<br>**Aim:** To examine effect of digital literacy on learners' civic engagement | **Technology:** Digital literacy<br>**Key findings:** Digital literacy improves civic engagement but requires infrastructure support |
| 10 | **Authors:** Vilakazi & Ebewo (2025)<br>**Country:** South Africa | **Study focus:** E-learning in TVET<br>**Aim:** To explore lecturer readiness and use of e-learning | **Technology:** E-learning<br>**Key findings:** Systems exist but are underutilised; lack of training and effective implementation |
| 11 | **Authors:** Dwayi (2015)<br>**Country:** South Africa | **Study focus:** ICT Teacher Development<br>**Aim:** To evaluate ICT professional development for lecturers in TVET colleges | **Technology:** ICT<br>**Key findings:** Training improves pedagogy and ICT adoption; sustainability challenges remain |

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| 12 | **Authors:** Nkrumah et al. (2023)<br>**Country:** Ghana | **Study focus:** Physical vs Digital Classrooms<br>**Aim:** To compare learning outcomes in digital vs traditional classrooms | **Technology:** E-learning<br>**Key findings:** Students prefer physical learning due to infrastructure challenges; need for improved support |
| 13 | **Authors:** Jantjies et al. (2018)<br>**Country:** South Africa | **Study focus:** VR and AR in Education<br>**Aim:** To explore potential of VR/AR in vocational learning | **Technology:** VR and AR<br>**Key findings:** VR/AR enhances experiential learning; requires further integration in TVET |
| 14 | **Authors:** Lukhele & Laseinde (2024)<br>**Country:** South Africa | **Study focus:** Cyber-Physical Learning<br>**Aim:** To assess readiness for virtual learning in engineering training | **Technology:** VR and CPS<br>**Key findings:** Equipment is outdated; strong need for virtual technologies to align with industry |
| 15 | **Authors:** Adegbenro et al. (2019)<br>**Country:** South Africa | **Study focus:** Teacher Technological Knowledge<br>**Aim:** To assess ICT knowledge among TVET teachers | **Technology:** ICT and TPACK<br>**Key findings:** Teacher knowledge is critical for effective digital integration |
| 16 | **Authors:** Edeh et al. (2021)<br>**Country:** Nigeria | **Study focus:** LMS Adoption in TVET<br>**Aim:** To examine factors influencing LMS use | **Technology:** LMS<br>**Key findings:** LMS adoption influenced by perception, experience, and gender |
| 17 | **Authors:** Olugbade et al. (2025)<br>**Country:** Nigeria | **Study focus:** AI Chatbots in Education<br>**Aim:** To evaluate AI chatbot use in learning | **Technology:** AI chatbot<br>**Key findings:** AI reduces cognitive load and improves learning outcomes |
| 18 | **Authors:** Naidoo & Dawuwa (2019)<br>**Country:** South Africa | **Study focus:** Technology Integration in TVET<br>**Aim:** To explore technology adoption challenges in TVET | **Technology:** ICT and blended learning<br>**Key findings:** Major barriers include infrastructure, resources, and digital literacy |
| 19 | **Authors:** Regassa & Desissa (2025)<br>**Country:** Ethiopia | **Study focus:** Technology Integration in TVET<br>**Aim:** To assess technology adoption and barriers in a TVET institution | **Technology:** ICT<br>**Key findings:** Infrastructure and digital literacy are major barriers; institutional support critical |
| 20 | **Authors:** Mogashoa & Makaring (2024)<br>**Country:** South Africa | **Study focus:** ICT in English Teaching<br>**Aim:** To explore ICT integration in teaching English | **Technology:** ICT<br>**Key findings:** Improves teaching but faces multi-level barriers (teacher, student, institutional) |
| 21 | **Authors:** Raban & Mayisela (2022)<br>**Country:** South Africa | **Study focus:** Enabling open learning through e-Learning<br>**Aim:** To explore the role of leadership in promoting e-learning | **Technology:** e-Learning and ICT<br>**Key findings:** Visionary and socially-just leadership styles positively contribute to e-learning adoption |

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| 22 | **Authors:** Telukdarie et al. (2025)<br>**Country:** South Africa | **Study focus:** VR integration and blended learning<br>**Aim:** Modernising vocational welding education through blended learning and virtual reality integration | **Technology:** VR<br>**Key findings:** Immersive technologies aid technology integration through VR |
| 23 | **Authors:** Makkonen et al. (2022)<br>**Country:** Ethiopia | **Study focus:** E-learning Services<br>**Aim:** Develop service level agreements (SLAs) for Ethiopian e-learning vocational teacher training using the service portfolio approach | **Technology:** ICT services<br>**Key findings:** Network issues hinder e-learning implementation |
| 24 | **Authors:** Aina & Ogegbo (2022)<br>**Country:** South Africa | **Study focus:** Virtual Classroom Transition<br>**Aim:** Investigating TVET college educators' experiences when transitioning from the traditional classroom to the virtual classroom during the COVID-19 | **Technology:** Online platforms<br>**Key findings:** Educators demonstrate a positive cognitive, affective and behavioural attitude towards transitioning to virtual learning |
| 25 | **Authors:** Ngqulu et al. (2019)<br>**Country:** South Africa | **Study focus:** TVET as eSkills Centres<br>**Aim:** Modelling TVET Colleges as Alternative Centres to Deliver eSkills Training in Rural Communities | **Technology:** ICT infrastructure<br>**Key findings:** TVETs can bridge e-Skills gap among rural communities but lack capacity |
| 26 | **Authors:** Schlebusch & Manyarela (2024)<br>**Country:** South Africa | **Study focus:** E-learning Perceptions<br>**Aim:** Exploring the experiences and perceptions of TVET students about e-learning. | **Technology:** E-learning<br>**Key findings:** Various elements obstruct e-learning opportunities in TVETs |
| 27 | **Authors:** Mitrovic et al.,(2023)<br>**Country:** South Africa | **Study focus:** OER for Entrepreneurship<br>**Aim:** To address the cybersecurity protection of TVET colleges through the development of a cybersecurity culture | **Technology:** Cybersecurity systems<br>**Key findings:** OER adoption enhances access and flexible learning |
| 28 | **Authors:** Roodt, S., & Ryklief, Y. (2022)<br>**Country:** South Africa | **Study focus:** Vocationalising Education<br>**Aim:** To explore the potential of DGBL to improve academic efficiency among vocational education students in South Africa | **Technology:** EdTech integration<br>**Key findings:** Digital Game-Based Learning (DGBL) technology improves skills relevance |

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| 29 | **Authors:** Konayuma (2018)<br>**Country:** Zambia | **Study focus:** Emerging Technologies in Education<br>**Aim:** To explore the possibilities of using Open Education Resources (OER's) and wiki's to support learning | **Technology:** AI, VR, OER's<br>**Key findings:** OERs supports immersive learning and improves teaching |
| 30 | **Authors:** Khoza, S. (2022)<br>**Country:** South Africa | **Study focus:** Digital Inequality in Education<br>**Aim:** To assess TVET college lecturers' instructional practices in classrooms | **Technology:** ICT infrastructure<br>**Key findings:** Inequality affects participation and outcomes |

### 4.6 Ethical considerations

This study is predicated on a scoping review of secondary data sourced from publicly available academic literature, specifically peer-reviewed articles indexed in reputable databases. Consequently, the research did not engage human participants, nor did it involve the collection of personal data or any form of primary data gathering. As such, formal ethical approval and informed consent were not requisite, in accordance with institutional and international research ethics guidelines. All sources incorporated into the review were meticulously cited and referenced to uphold academic integrity and mitigate the risk of plagiarism. The study adhered to principles of transparency, rigour, and responsible scholarship throughout the review process, which included the systematic identification, screening, and synthesis of literature consistent with the PRISMA-ScR framework.

## 5. Findings

The findings of this scoping review are presented in alignment with the research questions that guided the study. For each research question, we synthesize the evidence from the included studies, highlighting key patterns, opportunities, and challenges. The results are reported descriptively, supported by summary tables, figures and thematic groupings. This approach enables a clear and transparent presentation of the evidence base related to technology integration in African TVET education.

*RQ1: What types of digital technologies are currently used in TVET institutions across Africa to improve teaching and learning?*

In order to identify and categorise the types of digital technologies currently used in TVET institutions across Africa, the findings reveal a diverse but uneven landscape of technological adoption. As summarised in Table 1, the reviewed studies indicate a wide range of technologies, from basic ICT tools to more advanced and emerging digital solutions. These technologies can be grouped into several dominant groups, including: (i) ICT infrastructure and tools, (ii) e-learning and learning management systems, (iii) mobile and blended learning technologies, (iv) emerging technologies such as artificial intelligence, virtual reality, and cyber-physical systems, and (v) open and innovative digital learning approaches such as digital game-based learning and open educational resources (OERs).

The prevalence of ICT infrastructure and tools across the majority of studies reflects the foundational stage of digital transformation in many African TVET contexts. Basic ICT tools, including computers, internet connectivity, and digital platforms, remain central to teaching and learning processes. However, their utilisation is often constrained by accessibility challenges, limited infrastructure, and varying levels of digital literacy among both lecturers and students (Nwagwu, 2023; Regassa & Desissa, 2025). While these technologies facilitate content delivery and administrative functions, their

full pedagogical potential is not always realised due to contextual limitations such as poor connectivity and inadequate institutional support.

The adoption of e-learning systems and Learning Management Systems (LMS) also emerges as a prominent trend within the reviewed studies. These platforms are primarily utilised to support online and blended learning environments, enabling the delivery of course materials, assessment, and communication between lecturers and students. For example, studies indicate that LMS and flipped classroom approaches enhance student performance and provide opportunities for data-driven insights into learner behaviour (Kamal Eldeen et al., 2023; Edeh et al., 2021). Despite these benefits, the findings suggest that such systems are often underutilised due to limited training, poor system design, and low levels of user readiness (Vilakazi & Ebewo, 2025; Schlebusch & Manyarela, 2024). This highlights a disconnect between the availability of digital platforms and their effective pedagogical use.

MMobile learning and blended learning approaches represent another significant category of technologies identified in the review. These technologies are particularly pertinent in African contexts, where mobile devices are frequently more accessible than traditional computing infrastructure. Mobile learning facilitates flexible access to educational content, while blended learning integrates face-to-face and online instruction to enhance learning experiences (Makome et al., 2024; Raban & Mayisela, 2022). However, the findings indicate that the potential of these technologies is markedly constrained by high data costs, unreliable internet connectivity, and the lack of structured implementation frameworks. Consequently, while mobile and blended learning offer promising pathways for expanding access, their effectiveness remains highly contingent upon broader infrastructural and policy support.

A notable shift observed in the reviewed studies is the increasing integration of emerging technologies such as artificial intelligence (AI), virtual reality (VR), augmented reality (AR), and cyber-physical systems. These technologies are primarily utilised to create immersive, interactive, and practice-oriented learning environments that align with the demands of modern industry. For instance, VR and AR are used to simulate real-world scenarios, particularly in engineering and vocational training contexts, thereby enhancing experiential learning (Jantjies et al., 2018; Lukhele & Laseinde, 2024). Similarly, AI and chatbot technologies are employed to personalise learning and improve cognitive engagement (Omeh et al., 2025; Olugbade et al., 2024). Despite the significant benefits these technologies offer in terms of engagement and skill development, their adoption remains limited due to high costs, infrastructural requirements, and the need for specialised expertise, which many TVET institutions lack.

Lastly, the review highlights the increasing adoption of innovative digital learning approaches, including digital game-based learning (DGBL) and OERs. These technologies are employed to enhance student engagement, motivation, and access to learning materials. For instance, DGBL has been shown to improve academic efficiency and encourage active participation among vocational students (Roodt & Ryklief, 2022), while OERs help to reduce cost barriers and broaden access to education (Konayuma, 2018). From my perspective, these approaches are essential tools for promoting inclusive and equitable education, particularly in resource-constrained environments. However, their successful implementation depends on institutional readiness, digital literacy, and supportive policy frameworks.

In Figure 2, we present a keyword co-occurrence network generated using VOSviewer, which highlights the most prominent terms across the reviewed studies. With a minimum threshold of three occurrences, 13 keywords were identified, reflecting the dominant research trends. The network indicates that e-learning is the central and most interconnected keyword, underscoring its significance as the primary technological approach in technical and vocational education and

training (TVET). It is strongly linked to terms such as students, virtual reality, and teaching and learning, suggesting its role in facilitating flexible and interactive learning environments.

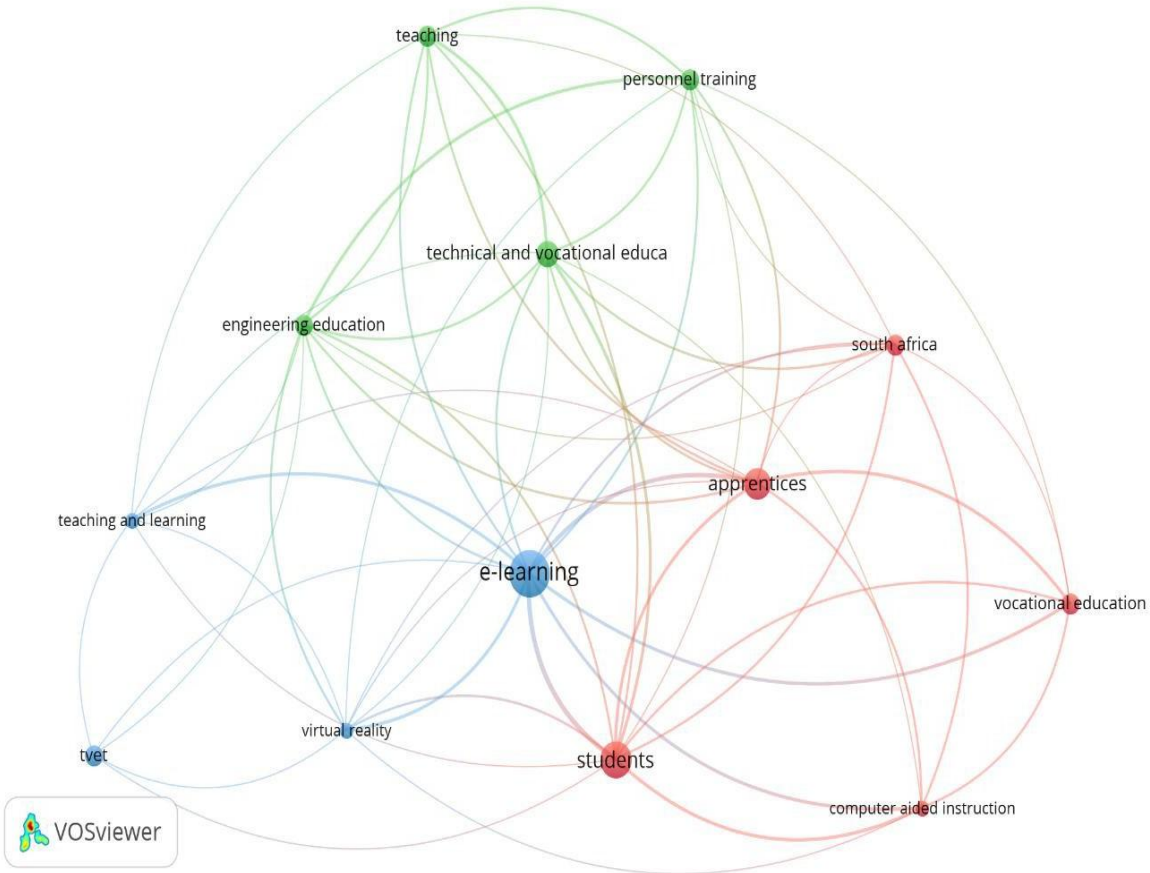


***Figure 2:*** *Keyword co-occurrence network of digital technologies in TVET*

Distinct clusters further reveal thematic groupings. One cluster connects technical and vocational education, engineering education, and personnel training, reflecting the alignment between technology use and skills development. Another cluster links students, apprentices, and computer-aided instruction, emphasising learner-centred applications. The presence of South Africa highlights its significant contribution to research. The network presented in Figure 2 suggests that while e-learning dominates, there is a growing integration of immersive and applied technologies in TVET.

*RQ2: Which African countries contribute significantly to research on technology integration in TVET education?*

In Figure 3, the distribution of the reviewed studies across African countries is presented, demonstrating a markedly uneven pattern of scholarly output. A significant proportion of publications originates from South Africa, which accounts for a substantially larger share of the studies (n = 19) in comparison to other countries. This dominance underscores South Africa's preeminent role in research pertaining to technology integration within TVET contexts, likely reflecting its comparatively advanced higher education and research infrastructure.

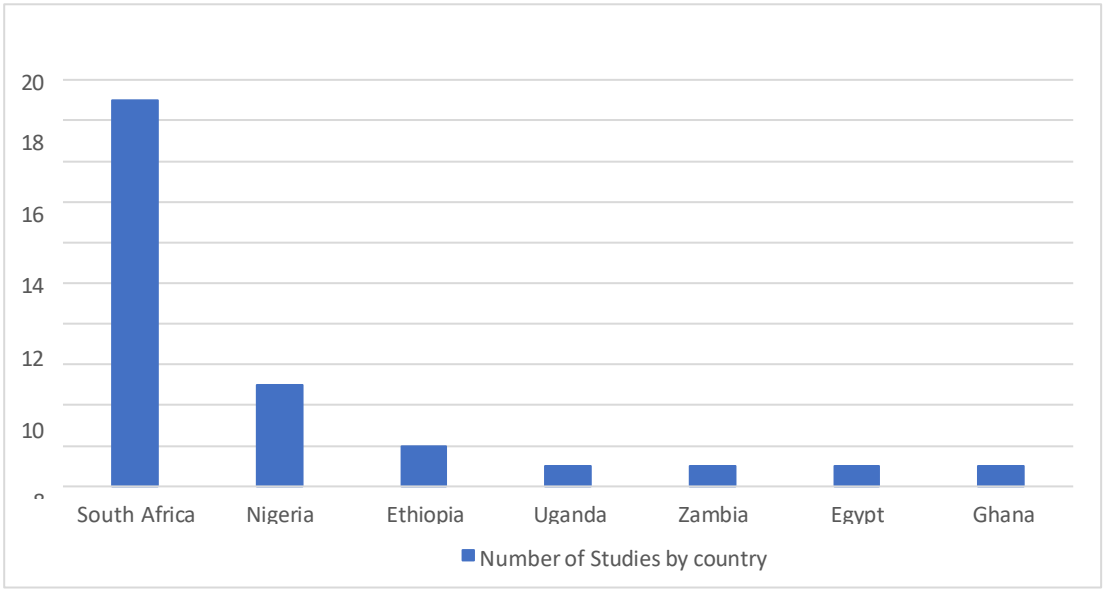


***Figure 3:*** *Distribution of publications by country*

In contrast, Nigeria accounts for a modest number of studies (n = 5), thereby positioning itself as the second most represented country in the dataset. Other nations, such as Ethiopia (n = 2), alongside Uganda, Zambia, Egypt, and Ghana (each with n = 1), exhibit minimal representation. This limited contribution from the majority of African countries indicates that research on technology integration in TVET remains underdeveloped across much of the continent. From a critical standpoint, the distribution highlights a significant geographical imbalance in the evidence base, characterised by a strong concentration of studies in a select few countries, while offering limited insights from others. This imbalance may adversely affect the generalisability of findings and underscores the necessity for more context-specific research within diverse TVET environments across Africa. Notably, the evidence suggests progress has been made in certain regions, juxtaposed with substantial gaps that persist in comprehending technology adoption in TVET throughout the continent.

Research Questions 3 and 4 are addressed concurrently because the challenges constraining technology integration and the opportunities for advancing digital transformation are closely interconnected. The evidence suggests that many of the institutional and pedagogical barriers identified across African TVET contexts also provide important areas for targeted intervention and future development. Accordingly, the following section synthesises the findings on the key institutional and pedagogical challenges affecting the adoption and effective use of digital technologies, while simultaneously highlighting the emerging opportunities through which these constraints may be addressed to strengthen digital transformation in TVET education across Africa

*RQ3: What institutional and pedagogical challenges influence the adoption and effective use of digital technologies in TVET education?*

*RQ4: What emerging opportunities exist for advancing digital transformation in TVET education across Africa?*

The following section addresses RQ3 and RQ4. The studies identified for the current review present a variety of ways in which TVET institutions across Africa adopt and utilise digital technology to transform pedagogy. Furthermore, this section highlights important emerging themes related to the challenges encountered by TVET institutions as they embrace various digital technologies in their teaching and learning practices. Table 2 presents a summary of the key themes that emerged from

this review. The themes are not mutually exclusive, and individual studies may contribute to more than one theme.

***Table 2:*** *Summary of key themes in technology integration among TVETs*

| Theme | Core Focus | Key insight | No. of studies |
|---|---|---|---|
| Technology-enabled pedagogies and flexible learning models | How technology is used in teaching and learning delivery | e-learning, blended learning, m-learning, flipped classrooms, OERs, virtual classrooms, digital game-based learning | 12 |
| Lecturer capability, technology acceptance, and pedagogical readiness | Human capacity to adopt and use technology effectively | ICT pedagogy, teacher knowledge, lecturer practices, acceptance models, professional development, readiness | 7 |
| Institutional readiness, leadership, and governance of digitisation | Organisational conditions shaping digital integration | leadership, implementation models, service design, AI ethics, digitisation frameworks, cybersecurity culture | 6 |
| Access to digital infrastructure, and the digital divide | Structural and contextual barriers to technology integration | connectivity, data costs, rural disadvantage, equipment shortages, physical access, internet access | 7 |
| Emerging technologies and innovative pathways in vocational training | Advanced technologies with potential to modernise TVET | AI, VR/AR, cyber-physical learning, analytics, simulation, immersive learning | 7 |
| Learner outcomes, inclusion, and wider social value | Educational and social benefits associated with digital use | performance, engagement, social justice, civic engagement, entrepreneurship, digital inclusion | 8 |

### 5.1 Theme 1: Technology-enabled pedagogies and flexible learning models

Twelve studies reported on the adoption of technology-enabled pedagogies and flexible learning modes among TVET institutions in Africa. This theme encompasses research examining how TVET institutions are utilising technology to transform teaching and learning through various strategies, such as e-learning, blended learning, m-learning, and flipped classrooms. Additionally, other authors have reported the use of digital teaching mechanisms, including digital game-based learning, OERs, and virtual classrooms. The findings indicate that a considerable number of TVET institutions have implemented these digital strategies to enhance pedagogy over the past ten years. This theme underscores the sudden shift among TVET institutions from traditional face-to-face learning

pathways to digitally enabled ones. The focus is on delivery models and pedagogical innovation rather than solely on institutional systems. Based on the studies examined in this review, this appears to be the largest cluster in the current dataset, underscoring the importance of adopting digital technology to facilitate teaching and learning in the 4IR era.

### 5.2 Theme 2: Lecturer capability, technology acceptance, and pedagogical readiness

This theme synthesises studies focusing on lecturer competence, digital confidence, teacher knowledge, ICT pedagogy, and the acceptance of technology within TVET contexts. Across the reviewed literature, seven studies consistently highlight the critical role of lecturer capability and pedagogical readiness in facilitating effective digital learning in African TVET institutions. For instance, Lukhele and Laseinde (2024) examined the readiness of TVET institutions to integrate virtual reality technologies in engineering training, revealing that South African institutions demonstrate a considerable level of preparedness for the adoption of such advanced technologies. However, the study emphasises that the successful implementation of these technologies is contingent upon lecturers' willingness to accept and integrate them into their teaching practices, supported by appropriate instructional strategies. Collectively, the studies within this theme suggest that technology integration extends beyond the provision of digital tools and platforms; it necessitates alignment with lecturers' pedagogical approaches, teaching philosophies, and ongoing professional development. In this regard, assessing the digital competence of lecturers becomes a crucial step in enabling effective adoption. As highlighted by Adegbenro et al. (2019), the development of digital skills among educators is fundamental to ensuring the successful integration of educational technologies. Furthermore, several studies employ the Technology Acceptance Model (TAM) to evaluate lecturer readiness, underscoring the importance of perceived usefulness and ease of use in shaping the adoption of technology within teaching practices.

### 5.3 Theme 3: Institutional readiness, leadership, and governance of digitisation

This theme highlights institutional readiness, leadership, and governance as critical factors influencing the integration of technology in African TVET institutions. Across six studies, these elements are consistently identified as key barriers shaping how effectively digital technologies are adopted for teaching and learning. The studies grouped under this theme collectively address issues such as digitisation models, implementation frameworks, service delivery structures, leadership support, project monitoring, AI policy development, and cybersecurity culture. A recurring finding is that successful technology integration is contingent upon the presence of enabling governance structures and clearly defined implementation processes. For instance, Muinda et al. (2025) developed a digitisation model for Ugandan TVET institutions, emphasising that effective implementation requires structured mechanisms to manage power dynamics and minimise political interference. Similarly, Makome et al. (2024) identified a lack of stakeholder awareness as a significant constraint, further compounded by contextual challenges such as high data costs and limited connectivity, which hinder the adoption of structured digital frameworks. As such, these findings suggest that institutional capacity extends beyond infrastructure to include strategic leadership, policy alignment, and continuous oversight. In addition, the studies underscore the importance of leadership commitment in driving digital transformation, including the formulation of clear AI-related policies and consistent monitoring of digitisation initiatives. Studies in this theme point to the notion that sustainable digitalisation in TVET institutions requires robust governance, proactive leadership, and coordinated institutional efforts.

### 5.4 Theme 4: Access to digital infrastructure, and the digital divide

A prominent theme that emerged from this review is the ongoing challenge of inadequate digital infrastructure within many African TVET systems, particularly in the least-developed contexts. The evidence consistently reveals structural limitations that hinder the effective adoption of digital

technologies for teaching and learning. Numerous studies report persistent issues related to poor connectivity, high data costs, and limited access to digital devices, all of which impede efforts to create fully digitally enabled learning environments. Additionally, the literature highlights related constraints, such as insufficient equipment, uneven resource distribution, and the disadvantages faced by rural institutions, which further exacerbate disparities in access to technology.

In essence, studies under this theme underscore the material conditions that continue to limit meaningful digital transformation in vocational education settings. Given that TVET institutions are often regarded as crucial access points for developing e-skills—especially in rural and semi-urban communities—the lack of reliable digital infrastructure poses a significant barrier to equitable education. This lack of access not only restricts students' ability to engage with digital learning platforms but also reinforces broader socio-economic inequalities. For instance, Regassa and Desissa (2025) highlight the situation in Ethiopia, where infrastructural deficiencies and limited institutional support considerably hinder the adoption of digital technologies in TVET institutions. Their findings indicate that unless these foundational challenges are addressed, efforts to integrate digital learning are unlikely to yield sustainable impact. Thus, the reviewed studies reinforce the argument that bridging the digital divide is essential for ensuring inclusive and effective technology integration in African TVET systems.

### 5.5 Theme 5: Emerging technologies and innovation pathways in vocational training

This theme includes studies that investigate the integration of advanced, industry-relevant technologies in TVET education, such as artificial intelligence, virtual and augmented reality, cyber-physical systems, educational data mining, simulation, digital game-based learning, and cybersecurity. Together, these studies indicate a clear shift from basic ICT adoption to more sophisticated technologies that meet evolving industry demands. A key finding within this theme is that digital game-based learning significantly enhances student engagement and academic performance.

In particular, gamified learning environments not only promote active participation and experiential learning but also improve knowledge retention and skill development (Roodt & Ryklief, 2022). Similarly, other studies emphasise the role of emerging technological tools in creating immersive learning environments that bridge the gap between theory and practice, thereby enhancing student engagement and supporting skill acquisition (Regassa & Desissa, 2025; Acevedo-Borrega et al., 2022). Findings in this area are further substantiated by evidence suggesting that such technologies contribute to the development of more engaging and interactive learning environments (Acevedo-Borrega et al., 2022).

Moreover, the literature consistently highlights the transformative potential of emerging technologies in reshaping teaching and learning practices through innovative and interactive approaches. For instance, advanced digital tools are shown to enhance experiential learning and facilitate the development of critical skills required in contemporary work environments (Edeh et al., 2021). In addition, several studies demonstrate that the integration of emerging technologies supports practice-oriented learning by enabling simulation-based and immersive experiences, which are essential for vocational training. This not only strengthens higher-order cognitive skills such as problem-solving and critical thinking but also contributes to the modernisation of educational practices in line with industry expectations (Makome et al., 2024).

### 5.6 Theme 6: Learner outcomes, inclusion, and wider social value

This final theme encompasses studies that connect the integration of educational technologies to broader outcomes, including student performance, academic efficiency, inclusion, social justice, civic engagement, support for entrepreneurship, and the development of community digital skills. Collectively, these studies broaden the discussion of technology use beyond classroom delivery,

highlighting its societal value within TVET contexts. Notably, several studies demonstrate how educational technologies can transform teaching and learning practices in resource-constrained environments by enhancing instructional delivery, while simultaneously revealing persistent inequalities related to infrastructure and connectivity (Kamal Eldeen et al., 2023). This dual role of technology as both an enabler and an indicator of inequality underscores the complexity of digital transformation in African TVET systems.

Moreover, the studies in this theme emphasise the significance of open and accessible learning initiatives in expanding educational opportunities. Research focusing on OERs and community-based learning models illustrates their potential to reduce cost barriers and improve accessibility, thereby bridging gaps related to affordability and participation (Raban & Mayisela, 2022). This is further supported by findings that indicate the adoption of such approaches promotes inclusive and equitable learning environments. Similarly, evidence suggests that digital literacy is crucial in enhancing learners' civic engagement by enabling them to critically interact with digital content and participate more actively in societal processes (Bessong et al., 2024). However, these benefits are not evenly distributed, as foundational digital competencies remain inconsistent across different contexts, reinforcing existing disparities.

Additionally, a growing body of research highlights how digital technologies facilitate interactive and learner-centred educational environments, thereby improving student engagement and overall learning experiences (Huang et al., 2024; Awidi & Paynter, 2024). Open learning initiatives, particularly in underprivileged communities, are recognised as important mechanisms for promoting inclusion and generating broader social value by addressing structural barriers to education (Nkrumah et al., 2023). Furthermore, innovative approaches such as digital game-based learning have been shown to enhance student engagement and academic efficiency within vocational education. Consequently, the studies within this theme illustrate that technology integration in TVET not only improves educational outcomes but also contributes to broader societal goals, including equity, participation, and socio-economic development.

## 6. Discussion

The primary aim of this study was to investigate the degree to which technology has been integrated into teaching and learning practices within African TVET institutions, as well as to identify the opportunities and challenges associated with this integration. Analysis of the 30 studies reveals that research output in this area is limited and unevenly distributed across the African continent. South Africa emerges as the most significant contributor, followed by Nigeria, Ethiopia, Uganda, Zambia, Egypt, and Ghana, with very few studies originating from other African countries. This pattern indicates that the discourse on digital transformation in TVET is still developing, with considerable gaps in continental representation. Furthermore, the studies reviewed highlight a diverse array of technologies being adopted, including learning management systems, mobile learning platforms, artificial intelligence, virtual and augmented reality, simulation tools, digital game-based learning, and open educational resources. This diversity reflects a gradual shift from basic ICT usage towards more advanced, industry-aligned technologies within TVET education.

From our perspective, the findings clearly indicate that while technology integration presents significant opportunities for transforming TVET teaching and learning practices, its implementation is hindered by multiple systemic challenges. In terms of technology-enabled pedagogies, this review argues that digital tools have the potential to enhance flexibility, interactivity, and learner-centred approaches. This is supported by studies grounded in the UTAUT framework, which highlight that digital pedagogies can enrich learning experiences and improve educational effectiveness (Al-Adwan et al., 2025). Viewed through the UTAUT lens, these findings suggest that lecturers are more likely to adopt digital pedagogies when they perceive them as enhancing teaching effectiveness and learner outcomes, reflecting the construct of performance expectancy (Venkatesh et al., 2003;

Venkatesh et al., 2012). However, the inconsistent availability of institutional support and technological resources points to weaknesses in facilitating conditions, which may limit sustained technology use despite positive perceptions of its pedagogical value. Additionally, these opportunities are often undermined by contextual limitations such as fragmented knowledge systems, uneven access to technological resources, and insufficient institutional support. Likewise, although e-learning is recognised as a promising alternative pedagogy in TVET, its effective implementation requires substantial investment in infrastructure and instructional design (Pangeni & Karki, 2021). We therefore assert that the success of technology-enabled pedagogies is highly dependent on contextual readiness and institutional support structures.

In terms of lecturer capability and pedagogical readiness, we assert that educators are vital to the success of digital transformation in TVET. The findings indicate that many lecturers lack the essential digital competencies, technological pedagogical knowledge, and confidence needed to effectively integrate technology into their teaching practices. This aligns with previous studies that identify digital self-efficacy, digital capital, and pedagogical competence as key factors for successful technology integration (Mbatha, 2024). Within the UTAUT framework, lecturer capability extends beyond technical skills to include effort expectancy; educators are more inclined to incorporate digital technologies when they perceive them as user-friendly and supported by adequate training (Venkatesh et al., 2003; Venkatesh et al., 2012). Consequently, this study reinforces the necessity of enhancing digital competence as a prerequisite for improving technology acceptance within TVET institutions. Furthermore, evidence suggests that many TVET lecturers possess limited skills in using advanced digital tools, such as blogs, video content, and online platforms, primarily due to insufficient training and institutional support (Nwandu et al., 2023). From our perspective, this reveals a significant gap in professional development, indicating that TVET institutions must prioritise ongoing training and capacity-building initiatives to enhance educators' readiness for technology adoption.

Institutional readiness and governance also emerge as critical factors influencing technology integration. The review found that without strong leadership, clear policy direction, and structured implementation frameworks, digital transformation efforts are unlikely to succeed. From the viewpoint of Socio-Technical Systems Theory (Baxter & Sommerville, 2011; Trist, 1981), these findings demonstrate that successful technology integration relies on the alignment of technological infrastructure with organisational structures, institutional leadership, policy frameworks, and human capabilities. The lack of this alignment undermines the sustainability of digital transformation initiatives, despite investments in technological resources. The findings suggest that many TVET institutions lack comprehensive ICT strategies, policy frameworks, and monitoring mechanisms, which jeopardises the sustainability of digital initiatives. This observation is supported by studies indicating that institutional readiness for the Fourth Industrial Revolution remains limited due to inadequate infrastructure, insufficient training, and weak policy directives (Denhere & Moloi, 2021). Moreover, the integration of emerging technologies, such as artificial intelligence, introduces additional governance challenges, including concerns regarding data privacy, algorithmic bias, and ethical use (Faisal et al., 2025). We therefore argue that effective digital transformation in TVET requires not only technological investment but also strong institutional governance and policy alignment.

A particularly critical issue highlighted in this study is the persistent digital divide, which continues to limit equitable access to technology across African TVET institutions. The findings clearly indicate that infrastructural challenges, including poor connectivity, high data costs, and limited access to digital devices, remain significant barriers to technology adoption. These challenges are especially pronounced in rural and underdeveloped regions, where TVET institutions are expected to serve as hubs for digital skills development. Supporting evidence suggests that students need basic technological competencies, such as proficiency in standard software applications and computer

literacy, to engage meaningfully in digital learning environments (Mbanga & Mtembu, 2020). However, the lack of infrastructure and access to resources continues to exclude many learners from these opportunities. Therefore, it can be argued that addressing the digital divide is essential for achieving inclusive and equitable digital transformation in African TVET education.

At the same time, the findings highlight the growing importance of emerging technologies in modernising vocational education. This study observed that technologies such as artificial intelligence, virtual reality, and digital game-based learning offer innovative pathways for enhancing experiential learning and aligning education with industry needs. These technologies have been shown to improve student engagement, motivation, and skill acquisition, particularly in vocational contexts where practical application is crucial (Maluleke & Maake, 2025). However, their adoption also introduces new challenges, especially regarding ethical considerations and the need for appropriate regulatory frameworks (Faisal et al., 2025). While emerging technologies present significant opportunities, their successful integration necessitates careful planning, governance, and capacity development. Consistent with STS Theory, the findings suggest that effective implementation of artificial intelligence, virtual reality, and other emerging technologies requires simultaneous investment in organisational capability, governance mechanisms, and human capacity. Technological innovation alone is insufficient unless it is supported by complementary institutional systems that enable its effective and ethical use (Baxter & Sommerville, 2011; Trist, 1981).

Moreover, the broader impact of technology integration on learner outcomes and social inclusion is evident across the reviewed studies. Digital technologies have the potential to enhance not only academic performance but also civic engagement, entrepreneurship, and community development. OERs and flexible learning models, for instance, play a critical role in expanding access to education and addressing affordability challenges. These findings demonstrate the complementary value of the two theoretical perspectives adopted in this study. While UTAUT explains the factors influencing lecturers' acceptance and use of digital technologies, the Socio-Technical Systems perspective broadens the analysis by illustrating how organisational, institutional, and socio-economic environments shape the sustainability of technology integration within African TVET education. However, the uneven distribution of digital resources and skills continues to limit these benefits. Therefore, it is important to emphasise that future research should focus on assessing the sustainability and effectiveness of digital interventions, particularly in under-resourced environments. There is an increasing need for more empirical studies to evaluate the long-term impact of technology-enhanced learning in TVET contexts (Orji & Perumal, 2024).

### 6.1 Implications and recommendations for TVET institutions

The findings of this review indicate that successful technology integration in African TVET institutions requires coordinated interventions across institutional, governmental, and industry levels. Instead of adopting isolated technology initiatives, digital transformation should be approached as a phased process that aligns technological infrastructure, human capacity, and institutional governance.

Firstly, the findings related to lecturer capability and pedagogical readiness suggest that TVET institutional management should prioritise continuous professional development. The review consistently identified inadequate digital competence and limited technological pedagogical knowledge among lecturers as significant barriers to effective technology integration. Therefore, institutions should invest in structured professional development programmes focused not only on digital literacy but also on the pedagogical integration of technology into vocational teaching. Establishing institutional communities of practice and peer mentoring initiatives would further strengthen collaborative learning and promote the sharing of effective digital teaching practices.

Secondly, the findings concerning institutional readiness and governance indicate that TVET executive leadership and institutional governing bodies should develop comprehensive digital transformation strategies supported by clear implementation plans, monitoring mechanisms, and policies governing the ethical use of emerging technologies. In line with the socio-technical systems perspective adopted in this study, technological investments should be accompanied by organisational reforms that enhance leadership commitment, digital governance, cybersecurity, and institutional accountability.

Thirdly, the review demonstrates that addressing the digital divide and infrastructure constraints should be a shared responsibility among national governments, education departments, telecommunications providers, and industry partners. Given the significant resource constraints facing many African TVET institutions, priority should be given to expanding reliable internet connectivity, improving access to affordable data, modernising digital infrastructure, and increasing the availability of digital devices, particularly in rural and underserved communities. These foundational investments represent enabling conditions for successful technology adoption and should precede the large-scale implementation of advanced digital innovations.

Lastly, the findings regarding emerging technologies and technology-enabled pedagogies suggest that TVET institutions and industry partners should adopt a phased approach to implementing technologies such as artificial intelligence, virtual reality, digital game-based learning, and open educational resources. Initial implementation should focus on pilot projects within programmes that have strong industry partnerships, allowing institutions to evaluate educational effectiveness, lecturer readiness, and resource requirements before a wider institutional rollout. Such an incremental strategy would minimise implementation risks while ensuring that technology adoption remains aligned with labour market needs and contributes to the development of digitally competent graduates. These recommendations align with the UTAUT proposition that technology adoption is influenced by performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh et al., 2003; Venkatesh et al., 2012), while simultaneously reflecting the socio-technical systems perspective that sustainable digital transformation requires alignment between technological, organisational, and human subsystems (Baxter & Sommerville, 2011; Trist, 1981).

## 7. Conclusion

This scoping review synthesised the current evidence on technology integration within African TVET institutions. While research in this field has increased over the past decade, the evidence base remains relatively limited and unevenly distributed across the continent. South Africa has emerged as the dominant contributor to the literature, followed by Nigeria, Ethiopia, Uganda, Ghana, Zambia, and Egypt, with many African countries remaining unrepresented. This geographical disparity highlights significant research gaps and broader inequalities in digital transformation, educational investment, and technology adoption across African TVET systems.

The review demonstrates that technology integration has considerable potential to transform teaching and learning by enhancing student engagement, supporting flexible and blended learning, and strengthening vocational skills development through more experiential and industry-aligned pedagogies. Furthermore, digital technologies—including learning management systems, mobile learning platforms, artificial intelligence, virtual and augmented reality, digital game-based learning, and open educational resources—contribute to the development of higher-order competencies such as critical thinking, problem-solving, collaboration, and digital literacy. However, the review also indicates that the successful integration of these technologies is significantly constrained by inadequate digital infrastructure, poor internet connectivity, high data costs, limited access to digital devices, insufficient lecturer digital competence, and weak institutional governance and policy frameworks.

Despite these contributions, several limitations should be acknowledged. First, the review relied on a relatively small body of literature drawn from a limited number of African countries, which restricts the generalisability of the findings across the continent. Second, while the provisional coding categories were initially informed by title and abstract screening to facilitate study organisation, the final themes were refined and validated through comprehensive full-text charting and thematic analysis. There remains the possibility that some contextual nuances were not fully captured during the initial screening stage. Third, the review included only studies published in English, potentially excluding relevant evidence published in other languages. Finally, the review was limited to studies retrieved from four major academic databases. Although these databases were selected to ensure broad disciplinary coverage and methodological quality, relevant studies indexed elsewhere or published as grey literature may not have been captured.

Future research should prioritise expanding the geographical scope of technology integration studies to include underrepresented African regions. Additionally, empirical, comparative, and longitudinal investigations should be undertaken to examine the long-term effectiveness and sustainability of digital technologies within TVET institutions. Greater attention should also be devoted to evaluating policy implementation, institutional digital readiness, digital inclusion, and the development of context-specific strategies that address the infrastructural, pedagogical, and organisational challenges shaping technology integration in African vocational education. Such research will contribute to a more comprehensive understanding of how digital transformation can support resilient, inclusive, and industry-responsive TVET systems across the African continent.

## 8. Declarations

**Author Contributions:** Conceptualisation (A.F.M.); Literature review (S.M.); methodology (A.F.M & S.M.); software (N/A.); validation (A.F.M & S.M); formal analysis (A.F.M.); investigation (A.F.M & S.M.); data curation (A.F.M) drafting and preparation (A.F.M & S.M.); review and editing (A.F.M.); supervision (N/A); project administration (A.F.M. & S.M.); funding acquisition (A.F.M.). All authors have read and approved the published version of the article.

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