VTE VOCATION, TECHNOLOGY & EDUCATION

REVIEW ARTICLE

# Bridging the digital divide through enterprise-TVET provider partnerships: Strategic insights on digital transformation in TVET in developing nations

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**ABSTRACT**

This article examines the critical role of enterprise-technical and vocational education and training (TVET) provider partnerships (ETPs) in addressing the digital divide and fostering digital transformation within TVET systems in developing nations. It highlights that while digital transformation is imperative for TVET to meet Industry 4.0 demands and enhance lifelong learning, developing nations face significant obstacles, such as inadequate digital infrastructure, unstable power supplies, high digital equipment costs, and a shortage of digitally proficient educators. The paper argues that the disconnect between training providers and enterprises is an underlying problem exacerbating these challenges. Through a review of existing literature and best practices, this article posits ETPs as a strategic solution. It examines specific ETP strategies, including investment in infrastructure and resources, co-development of educational materials, teacher capacity building, provision of learning management systems (LMS), and mentorship and apprenticeship program offers. The article emphasizes that ETPs can facilitate the transition from traditional to digitalized learning environments, enhance TVET curricula's relevance, and ultimately equip learners with the skills needed for the digital economy. While acknowledging ETPs' potential limitations, such as costs and conflicting commercial interests, it suggests mitigation strategies to ensure that these partnerships effectively support sustainable digital transformation in TVET within developing contexts.

**Key words:** enterprise-technical and vocational education and training provider partnerships, technical and vocational education and training, digital transformation, investment, transition

## INTRODUCTION

Technical and vocational education and training (TVET) plays a vital role in cultivating human capital in developing nations (Mhlongo *et al.*, 2023). It equips individuals with the practical skills and knowledge necessary to meet labor market demands, thereby fostering economic growth and reducing poverty. As

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Received: 21 April 2025; Revised: 11 May 2025; Accepted: 5 June 2025
https://doi.org/10.54844/vte.2025.0977

economies evolve, particularly with the rise of digital technologies rapidly changing job profiles, digital transformation is often positioned as a potential driving force for promoting lifelong learning and adaptable learning pathways (Grech & Camilleri, 2020; Zhong, 2024; Zhong & Juwaheer, 2024). Digital transformation in TVET not only prepares learners for specific careers, but also enhances their adaptability to changing job requirements, which is crucial in a rapidly digitizing world (Crittenden *et al.*, 2019). Industry 4.0, the key driver of the world's digital transition, is currently revolutionizing industrial processes and eliciting new requirements for skills and knowledge among the workforce globally. While adjustments are being made in some educational systems to adapt to Industry 4.0 and artificial intelligence's (AI) impact on training implementation cycles (Li, 2024), developing nations are suffering from digital divides, with limited access to advanced digital devices and unreliable Internet and electricity infrastructure, thereby hindering digital transformation in TVET in these disadvantaged areas. Furthermore, basic computer skills remain a challenge for many teachers in several developing nations (Marr, 2022), hindering their ability to use more sophisticated digital tools and effectively provide instruction mediated by information and communication technology (ICT). These inabilities could be attributed to a lack of tools and training necessary to use these technologies effectively (Deckker & Sumanasekara, 2025). This disparity also impacts students, particularly those from underserved neighborhoods who might not have access to the technology needed for instruction (Abuali & Ahmed, 2025). Therefore, digital divides have become a major obstacle to attaining inclusive and equitable TVET in developing nations.

To improve TVET quality and guarantee that all students have the skills required for the digital economy, training providers need to obtain the financing, teacher professional development opportunities, and cutting-edge technologies required to close digital divides by working with enterprises. Such enterprise-TVET provider partnerships (ETPs) can create a welcoming atmosphere that guarantees all teachers and students have the abilities and resources needed to prosper in a technologically advanced economy. The private sector must be involved in establishing supportive environments that ease the shift to digitalized learning and unleash TVET's potential in relevant skills development (Ranganai *et al.*, 2025). ETPs advocated for here should be evidence-based partnerships that actively works to overcome widespread digital divides and improve digital technology use among instructors so that TVET can fulfill its role in promoting economic growth in developing nations.

## TVET IN DEVELOPING NATIONS, DIGITAL TRANSFORMATION, AND ENTERPRISE PARTNERSHIPS: AN OVERVIEW OF KEY THEMES

### *The significance of TVET for developing nations*

TVET is vital for developing nations' socioeconomic advancement. First, the strong emphasis on TVET's significant role in sustainable economic development stems from its fundamental function as a provider of training, equipping individuals with the practical skills needed for the labor market, thereby contributing to economic growth and reducing unemployment rates. As United Nations Educational, Scientific and Cultural Organization's (UNESCO's) 2015 Recommendation on TVET asserts, TVET, in all its forms and contexts, focuses on providing all youth and adults with the necessary knowledge, skills, and competencies needed for work and life within a comprehensive lifelong learning framework (Subrahmanyam, 2022). Furthermore, TVET helps alleviate poverty by improving marginalized groups' employability, leading to broader benefits for communities (Ali Asadullah & Zafar Ullah, 2018). It also fosters social equity by providing educational opportunities to disadvantaged populations, including women and those in rural areas. Effective TVET programs collaborate with industries and enterprises to ensure that the skills taught align with current job market demands, thereby enhancing graduates' employability (Xiao & Zhang, 2022). Moreover, TVET supports lifelong learning by offering flexible training options that allow individuals to upskill or reskill throughout their careers (Watson, 1994). Its connection to several United Nations Sustainable Development Goals (SDGs), particularly Goal 4 (Quality Education) and Goal 8 (Decent Work and Economic Growth), underscores its role in promoting sustainable development (Lei & Abidin, 2024). There is also advocacy for policy reforms and investments within TVET to improve its effectiveness further, as TVET still encounters challenges, such as insufficient funding, inadequate infrastructures, and limited access to quality training (Olayele, 2022). Overall, the literature emphasizes TVET's crucial contribution to fostering economic growth, reducing poverty, promoting social inclusion, and supporting sustainable development in developing nations (Legusov *et al.*, 2022).

### *The digital transition's impact on TVET*

The digital transition has impacted the education sector significantly, particularly TVET as a key subsector of education that fuels the workforce (Lin & Pang, 2024).

Recent developments indicate a significant shift from the traditional personal computer (PC) Internet and consumer Internet and toward the mobile Internet and industrial Internet. This transition is accompanied by increasing integration of AI across various sectors, involving not only manufacturing, but also education and training (Parua & Yang, 2024). These changes reflect a broader trend in enhancing connectivity and leveraging advanced technologies to improve operational efficiency and learning experiences within the TVET sector. Various extant studies have highlighted the integration of digital technologies as a catalyst for enhancing teaching and learning processes (Wang *et al.*, 2024). Digital tools—such as online learning platforms, simulations, and virtual labs—facilitate personalized learning experiences, thereby making education more accessible and engaging for students (Rafiq *et al.*, 2024). Several drivers have been advocating for such digital transformation in TVET, including supportive government policies in various countries, the digital economy's growing importance, and the need for skills that align with emerging technologies—all aimed at equipping learners for the evolving job market and enhancing employability (Yang & Yang, 2024).

Therefore, TVET is currently being driven to undergo digital transformation in response to this impact. Digital transformation refers to a comprehensive and synchronized shift in culture, workforce, and technology that facilitates the development of new educational and operational models, fundamentally changing an institution's processes, strategic goals, and value proposition (Brooks & McCormack, 2020). According to Pelletier and Hutt (2021), digital transformation is the most advanced stage of TVET in the context of digital transition, as demonstrated in Figure 1.

Successful digital transformation in TVET is contingent on many factors. During the transformation process, access to reliable Internet and digital tools is crucial from a technical perspective. Meanwhile, curricula that incorporate digital skills and emerging technologies are essential for meeting industry demands. Furthermore, institutional support is of relevant importance, as training providers need investment in digital resources and faculty training opportunities. As the foundational framework of institutional policies, supportive government policies play a vital role in promoting digital transformation within TVET (Wang & Si, 2024). Collaboration with enterprises is also another key factor, as good ETPs ensure training's alignment with current job market needs and facilitates ongoing teacher professional development for effective delivery of digital content. Furthermore, learner readiness—including students' ability and willingness to engage with digital tools, availability of funding and resources, societal attitudes toward technology, and the broader economic environment—helps shape the digital transformation landscape in TVET (Yang & Yang, 2024).

There are several key dimensions for implementing digital transformation in TVET. One key dimension is the use of e-learning and blended learning models, combining traditional face-to-face instruction with online resources. These models have been demonstrated to improve student outcomes by allowing for flexible learning schedules and catering to diverse learning styles (Sharma & Saxena, 2025; Udeze, 2024). The second key dimension entails utilizing data analytics to track student progress and tailor interventions, thereby enhancing overall educational effectiveness (Pathak & Jain, 2025). Third, incorporation of digital technologies in TVET skills delivery is also crucial, as it helps bridge the skills gap by providing learners with industry-relevant training that aligns with current job market demands (Vasilev, 2024). Finally, virtual reality (VR) and augmented reality (AR) applications are becoming increasingly potent tools for mimicking real-world situations, enabling students to practice practical skills safely and effectively. This technological integration not only enhances the learning experience, but also prepares students for the digital economy (Iyer *et al.*, 2025).

### *ETPs' importance in TVET*

ETPs have gained traction as a strategy to enhance education and training systems, including TVET (Semali, 2024). While these partnerships also are commonly known as public-private partnerships (PPPs), ETPs specifically emphasize collaboration among all enterprises, whether government-owned or privately owned, to strengthen TVET. Extant research indicates that ETPs can mobilize resources, expertise, and innovation from both sectors effectively to improve educational outcomes. These collaborations foster a more responsive educational environment that aligns with industry needs, ultimately benefiting students and employers alike (Languille & Balsera, 2025). Several extant studies have demonstrated ETPs' effectiveness within various educational contexts. For example, private sector stakeholders' involvement in curriculum development ensures that training programs are relevant and up-to-date, equipping learners with the skills that employers require (Yu *et al.*, 2025). Furthermore, ETPs can enhance infrastructure development and provide access to modern technologies that are crucial for delivering quality TVET (Harikirishanan, 2024). However, the literature also highlights potential challenges associated with ETPs, such as the risk of prioritizing profit over educational quality and equity. Effective governance and clear frameworks are essential to ensuring that these partnerships serve the public interest and contribute positively to the education system (Kebede *et al.*, 2024).

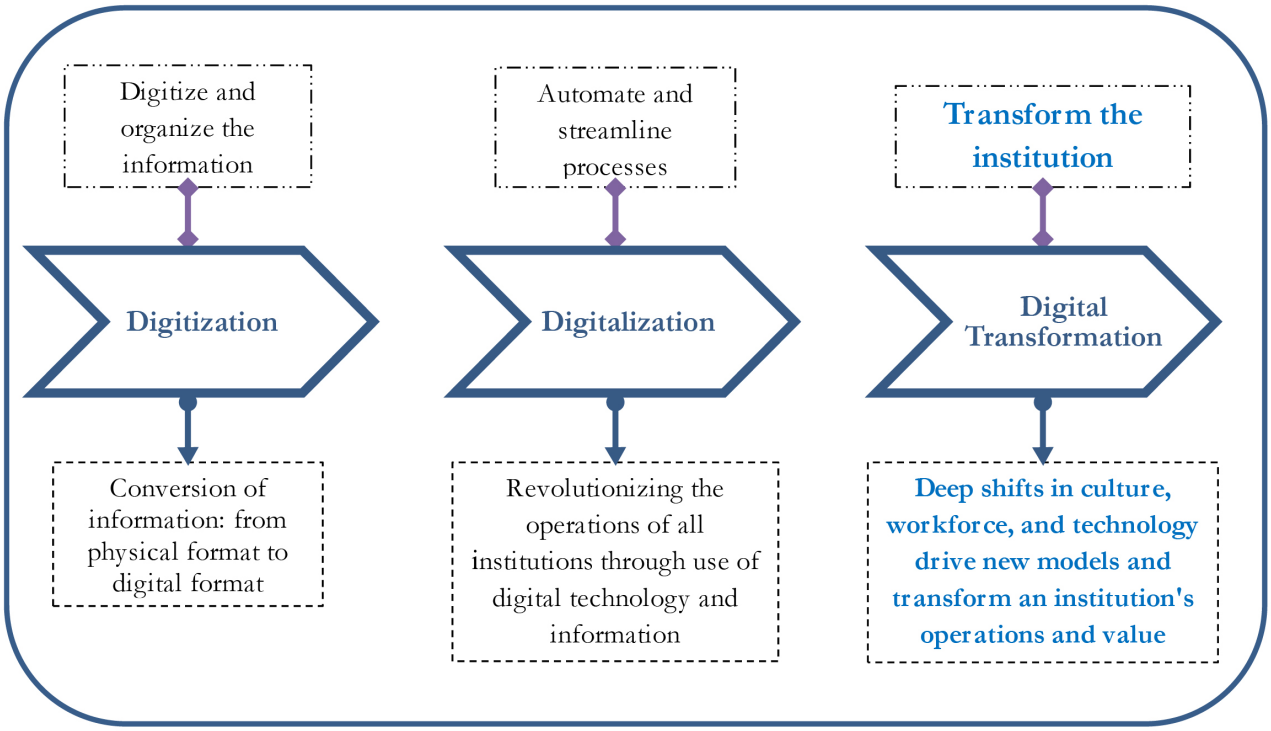


**Figure 1.** The stages of digital transformation in technical and vocational education and training.

Drawn from the literature above, digital transformation is the way forward for TVET to generate market-oriented learning outcomes, and ETPs could be the very bridge to this digital transformation destination as they offer opportunities that align educational programs with labor market needs. This article analyzes current challenges facing TVET in digital transformation to determine ETP strategies that can provide solutions to these challenges, thereby contributing to developing nations' skills development and socioeconomic progress.

## DIGITAL TRANSFORMATION'S IMPERATIVES AND CHALLENGES IN TVET

### *The need for digital transformation in TVET amid Industry 4.0*

The emergence of Industry 4.0, characterized by digital technologies, has been reshaping job requirements and skill sets needed in the modern workforce fundamentally. Characterized by integration of automation, AI, the Internet of Things (IoT), and big data, Industry 4.0 requires workers who are not only proficient in technical skills, but also adaptable to rapidly changing technologies (Zhong & Juwaheer, 2024). Traditional roles are evolving, with a growing emphasis on digital literacy, data analysis, and problem-solving skills. For example, manufacturing jobs now require knowledge of smart technologies and robotics, and logistics and supply chain management workers increasingly rely on data-driven decision-making. Moreover, soft skills—such as collaboration, communication, and critical thinking—are also becoming essential as teams become more interdisciplinary and remote. As industries embrace these advancements, the need for a workforce that can navigate this complex landscape is paramount.

In light of the latest workforce demands amid Industry 4.0, the need for robust reskilling and upskilling programs has never been more critical. As job roles evolve, workers must acquire new competencies to remain relevant and competitive in the job market. Reskilling initiatives focus on equipping individuals with entirely new skill sets for different roles, while upskilling enhances existing capabilities, enabling employees to leverage new technologies effectively. Educational institutions and organizations must collaborate to design flexible training programs that respond to industry-specific needs (Bashir, 2024), such as integrating hands-on training, online courses, and industry certifications that provide practical experience. Furthermore, lifelong learning should be promoted as a cultural norm, encouraging individuals to develop their skills throughout their careers continuously. By prioritizing reskilling and upskilling, we can create a workforce that is not only prepared for Industry 4.0 demands, but also

capable of driving innovation and economic growth in a rapidly changing world.

In particular, the need for reskilling is growing quickly due to disruptive technology's emergence. Through developments such as online purchasing, e-commerce, automated warehouse operations, and live classroom education, the global supply chain has experienced substantial changes in recent years. With the introduction of cutting-edge applications, new materials, and processes that make it possible to generate previously unthinkable goods and services, these disruptive technologies are opening up new possibilities for society (Li, 2024). As a result, employees in the manufacturing and service industries will need to acquire new skills. The workplace is already changing as a result of technologies such as cloud computing, mobile Internet, and AI. Even though 6G and quantum computing remain in their infancy, change is expected to happen quickly. All these changes are fueling the need for digital transformation in TVET.

### *The benefits of adopting digital technologies in TVET*

Digital technologies play a transformative role in TVET by enhancing access, collaboration, and skill development; simplifying admission processes; and providing essential resources, such as translators and grammar tools, thereby making education more accessible (Renkema & Tursunbayeva, 2024). Collaborative tools enable the sharing of presentations and materials, fostering an interactive learning environment, while video conferencing connects students and instructors globally, thereby overcoming geographical barriers. In countries such as South Korea, robust digital infrastructure allows for seamless learning experiences across all cities, ensuring that remote students have equal access to quality education. Furthermore, digital technologies facilitate ongoing skill development through online assessments and feedback, promoting continuous learning beyond traditional classrooms. Ultimately, digital technology serves as a catalyst for improving TVET, preparing a more competent and adaptable workforce to navigate modern job market challenges (Antoninis *et al.*, 2023).

Digital technologies are increasingly being integrated into TVET programs due to their benefits in transforming traditional learning environments into dynamic, interactive experiences (Mbatha, 2024). Many institutions are adopting blended learning models that combine online resources with face-to-face instruction, allowing students to access a wealth of information at their convenience. Virtual simulations and AR are being utilized to provide practical training experiences in fields such as engineering and healthcare, enabling learners to practice skills in a risk-free environment. Furthermore, LMS are becoming commonplace, facilitating course management, tracking progress, and enhancing communication between educators and students. With the rise of mobile learning, students can engage with educational content anytime and anywhere, further enriching their learning experience (Kanwar *et al.*, 2019).

Moreover, adoption of digital learning tools and platforms in TVET offers numerous advantages for both educators and students. For educators, these technologies streamline administrative tasks, allowing for more time for personalized instruction and student engagement. They can easily create and share resources, track student progress, and provide timely feedback (Munyaradzi *et al.*, 2024). For students, digital transformation enhances learning by offering access to interactive content, diverse learning materials, and real-time assessments that cater to various learning styles (Zhong & Juwaheer, 2024). This flexibility promotes self-directed learning, enabling students to progress at their own pace and develop critical digital competencies necessary for the modern workforce. Furthermore, the use of digital technologies fosters collaboration among students through online forums and group projects, preparing them for teamwork in their future careers.

### *Digital transformation's challenges in TVET in developing nations*

Despite numerous benefits, implementation of digital technologies in TVET elicits specific challenges. One significant hurdle is the digital divide in terms of infrastructure, in which disparities in access to technology and reliable Internet connectivity can limit opportunities for students living in developing nations lagging behind in digital technologies, particularly these nations' rural or underserved areas (Mthabela, 2024). Equipment costs, electricity infrastructure issues, and lack of experience among teachers are major obstacles. Each of these challenges plays a significant role in the digital transformation initiatives' overall effectiveness in TVET (Shambare & Jita, 2025). Digital education is severely hampered in emerging economies with irregular or insufficient access to electricity, in which frequent power outages can impair online learning and make it difficult for students and teachers to access instructional resources consistently (Singun, 2025). This issue is particularly pronounced in rural areas where infrastructure may be lacking. Reliance on digital platforms for education requires a stable power supply, which is often not available, thereby exacerbating digital divides and limiting access to quality education.

Specifically, one significant challenge is the expense associated with acquiring the necessary technological equipment. The costs of computers, tablets, and other

digital resources needed for effective online learning pose a barrier for many educational institutions (Mhlanga, 2024). This challenge is compounded by ongoing expenses for technology updates and maintenance, which can be financially burdensome for TVET institutions operating on tight budgets. If institutions cannot effectively integrate digital technologies into their curricula due to high equipment costs, digital education's potential benefits may be restricted significantly (Mesuwini & Mokoena, 2023).

Insufficient expertise among teachers is also a significant obstacle to implementing digital transformation in TVET. Many teachers lack the digital skills needed to incorporate technology into their teaching methods effectively (Althubyani, 2024). While the UNESCO Competence Framework for Educators emphasizes that digital literacy is crucial for teachers to support learning in a digital context, numerous teachers in emerging markets have not received sufficient training in digital tools and teaching strategies, resulting in ineffective instructional practices and low confidence in using technology. Therefore, many educators are unprepared to transition to ICT-mediated instruction. Their limited familiarity with digital technologies and skills could be further attributed to inadequate financial resources for digital equipment, lack of Internet connectivity, and the absence of expert guidance from the private sector, hindering their shift from traditional to cutting-edge content in the digital economy.

African countries exemplify the aforementioned challenges that developing nations face in their digital transformation of TVET. A situational analysis of TVET and skills development systems in Africa has highlighted that a lack of basic infrastructure, such as reliable electricity and widespread broadband Internet access, remains a fundamental barrier to digitalizing TVET (Grech, 2023). For example, Malawi's poor Internet connectivity affects more than 70% of rural areas, making TVET digital transformation more than difficult. Many of these nations—such as The Gambia, Liberia, and Mali—struggle to equip most teachers, instructors, and practitioners with the necessary digital and ICT skills for their day-to-day work functions (Grech, 2023). Furthermore, the report underscores that in many developing contexts, TVET curricula often do not align with the digitally transforming labor market's rapidly evolving demands, leading to a mismatch between skills supplied and demanded (Grech, 2023). In stark contrast, developed nations generally possess significant advantages in these dimensions, facilitating a smoother digital transformation in their TVET systems. For example, countries such as South Korea, with its world-leading digital infrastructure and near-universal high-speed broadband penetration, provide a robust foundation for advanced digital learning initiatives in TVET (Raihan & Shamim, 2013). Similarly, Finland has established comprehensive frameworks for continuous professional development of TVET teachers, including a strong emphasis on digital competencies and innovative pedagogical skills, ensuring that educators are well-prepared to integrate technology into teaching and learning effectively (Novoa-Echaurren *et al.*, 2025). As a result, the digital gap between developing and developed nations worsens inequalities by denying marginalized populations access to technology (Perumal & Orji, 2024).

### *Disconnect between training providers and enterprises as the underlying problem*

Amid the aforementioned challenges from digital transformation in TVET in developing nations, the disconnect between training providers and enterprises could be one of the more particularly relevant underlying problems because lack of collaboration with enterprises restricts opportunities for industrial support with facilities and equipment, TVET teacher professional development, and access to essential digital resources. The absence of enterprises in supporting the TVET sector may also undermine digital transformation initiatives' effectiveness and, therefore, constrain student engagement and improved learning outcomes' potential (Tuck, 2007).

Many examples of evidence of a disconnect between training providers and enterprises in developing nations can be found. In Uganda, one of the most important agents of TVET development is the Sector Skills Councils (SSCs), which are employer-led bodies that establish occupational standards and align curricula with industry demands. SSCs are now encouraging digital transformation of TVET, but have faced many enterprise support obstacles, including a lack of financing and resources from industrial donations, poor access to contemporary technology, and a shortage of qualified industrial instructors on digital tools from digital-tech firms. These obstacles make it more difficult to transform TVET delivery, thereby affecting Uganda's capacity to close its digital gap (Mutebi & Ferej, 2023). In Liberia, the TVET system has been damaged by civil conflict, resulting in the loss of skilled staff and facilities (McManus *et al.*, 2025). Low TVET enrollment has led to youth's lacking necessary skills for the digital economy, resulting in significant youth unemployment. To improve TVET, the Liberian government and assisting organizations, such as the World Bank and UNESCO, are making efforts on digital transformation of TVET (Grech, 2023). However, disconnect with enterprises—including ineffective communication channels, lack of alignment between industry demands and training programs, and a lack of resources from the private sector—has hindered government efforts to support digital transformation.

## RECOMMENDATIONS ON DIGITAL TRANSFORMATION IN TVET: ETPS AS THE PATH FORWARD

### *ETPs' role in bridging the digital divide*

Addressing these challenges requires a multifaceted approach that includes improving infrastructure, providing financial support for equipment, and investing in professional development for teachers. TVET institutions must establish external partnerships to create comprehensive digital transformation strategies that ensure equitable access to technology and training, thereby facilitating a smoother transition to digital education (Yang & Wu, 2024).

While integrating enterprises into the TVET framework remains a significant challenge, ETPs are being employed as a bridge across the digital divide (Khalid & Noor, 2025; Ministry of Education and Sports, 2019), with many countries recognizing TVET's importance in promoting economic development and workforce readiness. To this end, numerous governments have enacted laws and bills aimed at enhancing TVET implementation policies, which typically focus on increasing access to vocational training, improving education quality, and fostering partnerships between educational institutions and the private sector.

Successful ETPs in TVET have demonstrated the transformative potential of collaboration between educational institutions and the private sector. Notable examples of successful ETPs in TVET can be found in developed nations, one of which is the partnership between Siemens and various vocational schools worldwide, in which Siemens provides training equipment, curriculum development support, and industry expertise (Berenbach & Rayment, 2008). This collaboration has resulted in enhanced training programs that align closely with industry standards, producing graduates who are job-ready and equipped with the necessary skills. Another example is the collaboration between the Australian government and various industry leaders in the Skills for Education and Employment program, which aims to improve disadvantaged job seekers' employability through targeted training initiatives. This partnership has led to increased employment rates and improved skill levels among participants, demonstrating the effectiveness of aligning training with workforce needs. Other ETP practices in developed nations, which facilitate matches between skills development systems and the latest digital technology advancements, include International Business Machines Corporation (IBM) and the Pathways in Technology Early College High School (P-TECH) model (Abdul-Alim, 2017; Weldegiorgis & Davis, 2021), Coca-Cola and youth empowerment initiatives in TVET (Panzavolta, 2016), and Samsung and its various partnerships and initiatives aimed at enhancing skill development and fostering innovation (Nahm, 2017; Shin & Cho, 2020; Yusuf, 2023).

The benefits of ETPs in TVET are manifold, impacting educators, students, and the broader economy. For educators, these collaborations provide access to industry expertise, resources, and training materials that enhance teaching quality. Students benefit from exposure to real-world applications of their skills, increasing their employability and readiness for the workforce. Furthermore, partnerships can lead to development of innovative training programs that keep pace with technological advancements, ensuring that graduates possess relevant skills. From an economic perspective, these collaborations contribute to a more skilled workforce that meets industry demands, ultimately driving productivity and competitiveness in the labor market. By aligning educational outcomes with employers' needs, ETPs can improve job prospects for graduates in developing nations significantly and thereby close the digital divide.

### *Best ETP practices for digital transformation in developing nations*

While developed countries have demonstrated promising conditions and practices for the digital transformation of TVET, it is more important to highlight and analyze best ETP practices from developing nations (below), which might offer valuable insights for digital transformation efforts.

#### *Partnerships in the telecommunications sector in Uganda*

Telecommunications companies such as Mobile Telephone Network (MTN) and Airtel have played a pivotal role in supporting TVET institutions in Uganda. Through the ETP, MTN has enhanced ICT training by providing resources, infrastructure improvements, and expertise for curriculum development (Moses, 2020). Airtel has engaged in initiatives aimed at promoting digital literacy, including workshops and training sessions that focus on telecommunications and mobile technology. By investing in these educational initiatives, MTN Uganda and Airtel Uganda are helping to bridge the skills gap and contribute to the growth of a knowledgeable workforce equipped to meet the evolving digital landscape's demands.

#### *Partnerships in the energy sector in Malawi*

In Malawi, Eskom**,** the South African public electricity utility, has supported skills development in the energy sector significantly through TVET capacity-building initiatives (Ho *et al.*, 2023). Eskom has invested in

capacity-building initiatives for educators, improving the quality of instruction and aligning curricula with industry standards. The utility has also supported the development and upgrading of training facilities to ensure that students have access to modern digital equipment. Furthermore, it offers internships and practical training placements for TVET students to gain real-world experience in preparation for the digitalized world of work. By forming partnerships with local organizations and government bodies, Eskom promotes awareness of TVET digital transformation's importance in addressing Malawi's skills needs in the energy sector.

### *Private Sector Foundation Uganda's (PSFU) sponsorship in TVET*

PSFU sponsors several impactful programs aimed at enhancing TVET and promoting digital transformation nationwide (Nuwagaba, 2012). They collaborate with institutions to improve vocational training curricula in sectors such as agriculture, hospitality, and construction. In urban centers such as Kampala, PSFU organizes workshops to enhance digital literacy among entrepreneurs and students, focusing on e-commerce and digital marketing skills. PSFU also provides capacity-building workshops for rural and semi-urban areas, emphasizing operational efficiency and integration of digital solutions to support their navigation of the digital divide. Through these initiatives, the PSFU is making significant strides in enhancing skills and fostering digital transformation of TVET across Uganda.

### *University-industry linkages in China*

In China, the largest developing nation, a robust ecosystem of partnerships between universities and leading companies drives innovation and skill development in TVET. The leading TVET institution in China, Shenzhen Polytechnic University (SZPU), has established partnerships with leading companies—such as BYD, Huawei, and Alibaba—to co-develop curricula that include guest lectures and joint research projects on dealing with digital transformation (Yang & Wu, 2024). SZPU has developed a structured collaboration approach known as the "Nine Joint Actions With Industry Sectors", emphasizing comprehensive cooperation with industry stakeholders (Lin & Pang, 2024), joint governance and cultivation of institutional and corporate culture, joint design and development of program syllabi and curricula tailored to industry needs, joint creation and development of specialized faculty teams, joint research initiatives focusing on applied technologies, joint formulation and dissemination of industry-specific standards, joint development and certification of vocational qualifications, joint provision of innovation and entrepreneurship training, joint engagement in modern apprenticeship programs and community service initiatives, and joint establishment of overseas TVET skill development centers to enhance international collaboration. To implement this collaboration model effectively, SZPU has established 18 industrial colleges in partnership with prominent enterprises. These industrial colleges serve as platforms for executing the nine joint actions, enabling SZPU to harness cutting-edge industry expertise and the enterprise partners to prepare relevant labor cost-effectively (Lin & Pang, 2024).

### *Global technology leader partnerships in TVET*

Huawei, a global leader in digital technologies, is at the forefront of collaborations with TVET institutions (Calzati, 2023). By partnering with various educational organizations worldwide that encompasses many developing nations, Huawei provides cutting-edge technology, training resources, and expertise to help institutions develop curricula that align with industry needs. These collaborations focus on equipping learners with essential ICT and AI skills, fostering innovation, and preparing a workforce that can thrive in a technology-driven economy (Seyoum, 2022). Through initiatives such as training programs, workshops, and resource sharing, Huawei is contributing significantly to the advancement of TVET, ensuring that graduates are well-prepared for modern job market challenges.

## ***Specific ETP strategies for digital transformation of TVET: insights from current status and best practices***

Specifically, several dimensions are relevant to digital transformation in TVET in which ETPs could play a role.

### *Investment in infrastructure and resources*

Investment in infrastructure is vital for establishing an environment conducive to digital learning. Private sector engagement can take several forms, such as upgrading technology infrastructure, providing equipment and resources, and building modern learning spaces. Companies can invest in enhancing educational institutions' technological infrastructure, including improving Internet connectivity, upgrading computer labs, and providing multimedia resources. This ensures that both educators and students have access to the necessary tools for effective teaching and learning. Companies can donate or subsidize essential equipment, such as computers, tablets, and software licenses. This support reduces the financial burden on educational institutions and enhances their capacity to deliver high-quality education. Furthermore, collaborating with educational institutions to create modern learning environments equipped with technology can foster an engaging atmosphere that encourages collaboration and innovation. By investing in these spaces, businesses can help facilitate dynamic learning experiences that better prepare students for the digital economy.

### *Co-development and distribution of educational resources*

The private sector can help co-create high-quality educational content significantly with training tools such as textbooks, videos, and interactive modules that align with TVET curricula. To maximize benefits, these resources could be made available at a low cost or as open education resources (OERs), through which enterprises can facilitate distribution of OERs through platforms that simplify access for educators, enabling them to integrate these valuable resources into their teaching. Most importantly, no matter what form of educational resources is involved, it is essential to promote close collaboration among educators, industry experts, and content creators in content development to meet learners' needs from an educational perspective and ensure relevance from a job market perspective. This collaborative approach not only accelerates the digital transformation of TVET through digitization of educational resources, but also significantly enhances the TVET curricula's effectiveness by updating content in response to the digital economy.

### *Building teacher capacity for digital transformation of TVET*

Enterprises are promising capacity-building agencies for TVET teachers to get prepared for digital transformation. For enterprises in specific sectors, workshops and seminars could be organized to engage TVET teachers with emerging technologies and digital skills relevant to their corresponding sector or industry. For technological companies, research and development initiatives could be implemented in collaboration with educational institutions to examine the latest developments in digital technologies. For EdTech companies and teacher training agencies, innovative teaching methods and digital pedagogies could be piloted in training providers by offering teacher training workshops and piloting activities. Such partnerships enhance teachers' digital capabilities, fostering innovative educational practices that improve TVET learning outcomes.

### *Providing learning management systems*

LMS are essential tools that enhance online learning and streamline resource management in educational settings. Many enterprises already have developed LMS for employee training. These systems can also be shared with training providers, enabling educators to create, manage, and deliver educational content online effectively. These platforms should include features such as course tracking, assessments, and communication tools, which facilitate meaningful interactions between educators and students. By equipping institutions with robust LMS solutions, businesses can enhance teaching and learning experiences significantly, making them more efficient and accessible. In addition to providing LMS, companies can offer training sessions for educators on how to use these platforms effectively. This ensures that teachers are not only familiar with the technology but also capable of utilizing it to enhance the learning experience. Businesses can work with TVET providers to customize LMS, according to specific curriculum needs, thereby providing ongoing technical support to ensure smooth operation. This tailored approach will foster a more effective and user-friendly digital learning environment.

### *Offering mentorship, internship, and apprenticeship programs*

Establishing mentorship programs in which industry professionals guide and support students can enhance the learning experience. Mentorship can provide valuable insights into industry expectations and help students develop the skills necessary for success in the workplace. Also, enterprises can provide internship and apprenticeship opportunities for students enrolled in TVET programs. These hands-on experiences not only enhance students' practical skills, but also foster connections between learners and potential employers, making the transition from education to employment smoother.

## ***Limitations of ETPs in digital transformation of TVET and navigating the pitfalls***

While ETPs have been demonstrated to offer significant potential for bridging the digital divide in TVET within developing nations, it is crucial to acknowledge potential limitations and challenges inherent in these collaborations. Above all, associated technology and resources with digital transformation could be provided by enterprises at high prices that educational institutions cannot afford. This creates a barrier to implementing modern training programs that incorporate essential digital components (Harikirishanan, 2024). Even though there are affordable or free resources and services available for training providers, it is inherent that enterprises are fundamentally driven by their own commercial interests, which can lead to potential conflicts of interest within partnerships. This may manifest as partners prioritizing adoption or promotion of their specific technologies, products, or methodologies within TVET curricula and training programs. Such actions, while potentially introducing valuable industry-specific knowledge, could inadvertently influence the direction of vocational training based more on a company's market strategy or advantage, rather than the broader, best interests of the students or the region's diverse, long-term economic development needs. Furthermore, these partnerships may have inherent limitations in terms of fundamental, systemic challenges they can address realistically. While an ETP can provide valuable resources such as modern digital

equipment, relevant content, or connectivity solutions within the training center, it may not be equipped or able to resolve underlying, basic infrastructural deficits that plague many developing nations. Issues such as inconsistent and unstable power supplies, or limited widespread access to affordable and reliable Internet infrastructure outside of specific partnership-supported sites, pose significant barriers to digital transformation on a broader scale.

To navigate the aforementioned pitfalls as much as possible, deliberate and strategic approaches are required from both TVET providers and governmental bodies. First, establishing robust governance structures and fostering strategic leadership within TVET institutions is paramount because bureaucratic hurdles, inconsistent policies, and a lack of clear frameworks for collaboration can impede the establishment and sustainability of partnerships (Asuamah Yeboah, 2024). These robust governance structures also ensure institutional autonomy and help negotiate terms that prioritize educational benefits over purely commercial interests. Second, to address the incentive gap, the collaboration should advocate for the establishment of well-designed incentive programs. Government incentives—such as targeted tax breaks for companies investing in TVET infrastructure, providing apprenticeships, and contributing to curriculum development—can motivate enterprises to participate actively. Publicly recognizing and awarding enterprises for their involvement in TVET initiatives enhance their corporate social responsibility profiles and encourages their engagement. Third, fostering a win-win partnership between training providers and enterprises is key to making ETPs truly effective and sustainable. For example, joint research initiatives between industry experts and TVET educators can also foster innovation, allowing both parties to collaborate on projects that benefit their respective sectors and enrich learning content. Also, organizing regular networking events, workshops, and forums allows industry leaders and educators to discuss shared challenges, build trust, and examine concrete opportunities for collaboration beyond simple resource donation. Finally, implementing continuous feedback mechanisms involving students, educators, and employers throughout the pilot and subsequent phases is crucial to refining ETP initiatives, thereby ensuring they meet the evolving needs and expectations of all stakeholders involved.

## CONCLUSION

This review systematically examined and underscored ETPs' critical role as a strategic imperative for navigating the digital divide and fostering substantive digital transformation within TVET systems in developing nations. The synthesis of information presented throughout this article confirms that the journey toward digital transformation in TVET is fraught with significant challenges endemic to developing contexts. These include inadequate digital infrastructure, unreliable power supplies, the prohibitive costs of digital equipment and resources, and a critical shortage of educators equipped with the necessary digital competencies. Critically, this review also highlighted how a persistent disconnect between training providers and the enterprise sector often exacerbates these obstacles, hindering access to vital industry expertise, resources, and real-world learning opportunities.

In response to these multifaceted challenges, this article collated and analyzed a range of ETP strategies that—according to the reviewed literature and presented case studies from regions including Uganda, Malawi, and China—offer viable pathways forward. The key ETP approaches identified and elaborated upon include targeted investments in infrastructure and digital resources, co-development and distribution of industry-relevant educational materials, potentially as OERs, comprehensive initiatives for building teacher capacity in digital pedagogies; provision and customization of LMS by enterprises, and establishment of impactful mentorship, internship, and apprenticeship programs. These strategies, as the review indicates, collectively work toward creating a more dynamic, responsive, and ICT-enabled TVET ecosystem.

However, this review has also acknowledged, based on the information synthesized, that ETP initiatives are not without their limitations. Potential pitfalls were identified, such as the high cost of enterprise-provided technologies, conflicts arising from commercial interests, and partnerships' inability to address deep-rooted systemic infrastructural deficits alone. Consequently, the article has elicited insights on navigating these challenges through robust governance structures and well-designed incentive programs, thereby fostering win-win scenarios and continuous feedback mechanisms.

Looking ahead, and drawing from this review's scope, it is evident that strategic implementation and refinement of ETP models remain crucial for developing nations striving for digital equity in TVET. As this paper's outlook suggests, the field would benefit from further empirical evaluations into practical outcomes of diverse ETP models within various national and regional contexts. This includes a deeper examination of how different partnership structures impact teacher competencies, student learning achievements in digital skills, and TVET infrastructure's overall quality. Further examination into effective governmental policies and incentive structures that promote sustainable and equitable ETPs also is warranted, alongside strategies to mitigate implementation challenges. Ultimately, as this

review has endeavored to demonstrate, optimizing ETPs as a catalyst for digital transformation can provide invaluable contributions for policymakers, educators, and industry partners dedicated to advancing TVET and empowering the workforce in developing nations for the digital future.

## DECLARATIONS

### *Acknowledgement*
None.

### *Author contributions*
Niwamanya G: Conceptualization, Methodology, Writing—Original draft preparation. Zhong ZY: Writing—Review and Editing, Supervision, and Project administration. Matola CA: Investigation. Eliachu D: Data curation. Ravindra S: Software, Resources. Fahn JB: Validation. All authors have read and approved the final version.

### *Source of funding*
This research was supported by 2024 Research Project of Shenzhen Education Sciences under the "14th Five-Year Plan"—Research on Practical Strategies to Develop High-Quality Collaboration Between TVET Institutions in Shenzhen and International Organizations (No. yb24027).

### *Ethics approval*
Not applicable.

### *Informed consent*
Not applicable.

### *Conflict of interest*
The authors have no conflicts of interest to declare.

### *Data availability statement*
All data has been included in this paper.

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