A REVIEW OF DIGITAL TECHNOLOGY FOR TRANSFORMATION OF VOCATIONAL AND TECHNICAL EDUCATION

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Abstract
In recent years, the integration of digital technologies into vocational and technical education (VTE) has become a key driver for improving learning outcomes, closing skills gaps, and promoting equity and access. This review explores current studies and practices involving the use of digital tools—including augmented and virtual reality, simulation software, e-learning platforms, mobile applications, cloud services, and Internet of Things (IoT) devices—and evaluates their influence on pedagogy, learner engagement, instructor roles, and institutional capacity. This review highlights on the concepts of vocational and technical education (VTE), digital technology and educational transformation. It further highlights on the theories guiding the study, types of digital technologies used in VTE, their roles and benefits, challenges and need for transformation and purposes. The review also recommends future research needs such as long-term impact assessments, cost–benefit studies, and investigations into emerging innovations like artificial intelligence and immersive virtual environments to further improve the effectiveness and scalability of VTE across varied socio-economic settings and conclusion.

Keywords: Digital technologies, vocational and technical education, *Technical* and vocational *Education and Training.*

Introduction
Vocational and Technical Education (VTE) refers to programs designed to develop practical skills, competencies, and technical knowledge for careers in fields such as industry, agriculture, commerce, and services. Okoye and Okwelle (2013) describe VTE as the aspect of education that equips individuals with applied and scientific knowledge needed for professional practice. Similarly, UNESCO and ILO (2002) define Technical and Vocational Education and Training (TVET) as educational processes that combine general education with the study of technology and applied sciences, alongside the acquisition of practical skills, attitudes, and knowledge relevant to various occupational and social contexts.

Digital technology, on the other hand, includes electronic tools, systems, and resources used to generate, store, and process data. Examples range from computers, the internet, and mobile devices to artificial intelligence, virtual reality, and the Internet of Things (IoT). According to Hennessy, Harrison, and Wamakote (2010), digital technologies encompass communication and information management tools such as the internet, broadcasting, mobile phones, and computer-based applications. In education, these technologies support teaching and learning through multimedia, online platforms, digital simulations, and tools for remote collaboration.

Educational transformation refers to deep and systemic changes within educational structures, pedagogies, and outcomes. It involves rethinking curriculum, instructional strategies, assessment, and the roles of both teachers and learners in order to meet modern social and economic demands—often facilitated by technology. Fullan (2007) emphasizes that transformation is not about superficial reforms but about reshaping the culture of teaching and learning. Likewise, UNESCO (2015) views educational transformation as the process of reimagining education systems to prepare learners with the knowledge, skills, and values required in the 21st century.

Theoretical framework:

1.**Technological Pedagogical Content Knowledge (TPACK) Framework**
The TPACK framework, developed by Mishra and Koehler (2006), highlights the need to integrate three core areas of knowledge for successful use of technology in teaching. These include: Content Knowledge (CK), which refers to a sound grasp of the subject matter; Pedagogical Knowledge (PK), which relates to effective teaching methods and instructional strategies; and Technological Knowledge (TK), which involves familiarity with digital tools and their practical application. In Vocational and Technical Education (VTE), TPACK can be applied in different ways for example, having expertise in engine systems (CK), employing hands-on instructional strategies to engage learners (PK), and making use of simulation software for practice (TK). For instructors to deliver technical courses effectively with technology, they must combine all three components. As an illustration, teaching auto mechanics through virtual simulations requires adequate hardware resources such as high-performance computers, VR headsets and controllers, haptic devices, large screens or projectors for group demonstrations, along with a stable and backup power supply.

2. Substitution, Augmentation, Modification, Redefinition Model (SAMR Model) was proposed by **Ruben Puentedura (2006). The SAMR model describes four levels of technology integration:** Substitution – which means that tech replaces traditional tools (e.g., eBooks instead of textbooks), Augmentation – this means that tech adds functional improvements (e.g., using multimedia to explain processes), Modification – this has to do with the redesigning of learning tasks using tech (e.g., collaborative Google Docs projects) and Redefinition – which is all about the creation of entirely new learning experiences (e.g., remote-controlled robotics projects via the Internet). The application of this model is very useful because it is helping VTE educators' transit from basic use of technology (e.g., PowerPoint) to more transformative uses (e.g., using AR/VR to simulate electrical installations)

3. **Constructivist Learning Theory. This theory was proposed by** Jean Piaget, expanded by Vygotsky (1978). Constructivism argues that learners construct knowledge through experiences and active engagement rather than passive absorption. This theory is applied in VTE in the area of digital tools (e.g., simulations, virtual labs, game-based learning, and project-based tasks) adoption. It allows VTE learners to: Explore, Experiment, fail safely and build real-world knowledge and skills through doing.

4. **Connectivism**
This theory was proposed by George Siemens (2005). Connectivism is a learning theory for the digital age, suggesting that knowledge is distributed across a network of connections. Learning consists of the ability to construct and navigate these networks. The application of this theory in VTE is especially relevant for online and blended learning environments in VTE. Learners connect with peers, instructors, digital tools, and online resources, forming networks of learning. Examples include: Learning on LMS platforms (e.g., Moodle), Participating in online communities of practice, collaborating via tools like Microsoft Teams or Zoom.

5. Diffusion of Innovation Theory was proposed.
This theory was propounded by Everett Rogers (1962). The theory explains how innovations (such as digital technologies) spread through social systems. Adoption depends on: Relative advantage, Compatibility, Complexity, Trialability, Observability. The application of this theory in VTE is that it helps institutions and policymakers promote digital technology adoption in VTE by demonstrating benefits (e.g., improved employability), Providing training, Piloting technologies before large-scale deployment.

6. **Activity Theory was proposed by** Engeström (1987), building on Vygotsky principles. This theory looks at how people use tools (like digital technology) in a social context to achieve goals. It analyzes components like the subject, object (goal), tools, community, rules, and division of labor. The application of Activity Theory in VTE is that it is useful in **work-based learning contexts**, where learners interact with real-life tools and communities (e.g., online collaborative platforms) in authentic problem-solving scenarios.

Types of Digital Technologies Used in VTE and their applications

1. **Learning Management Systems (LMS) and Online Platforms.** Tools such as Moodle, Google Classroom, and Blackboard are used for delivering course materials, assignments, assessments, and managing student progress.
2. **Simulation Software**. These tools provide virtual training environments that mimic real-world processes (e.g., flight simulators, engineering design tools, and virtual labs). It also helps students practice skills safely and cost-effectively.
3. **Virtual Reality (VR) and Augmented Reality (AR)**: VR immerses learners in a fully digital environment, while AR overlays digital elements on the real world. They are used in medical training, technical repair, construction, for welding, carpentry, automotive training and design fields.
4. **Mobile Applications**. Educational apps that support skill acquisition, tutorials, and on-the-go learning. Examples are: Duolingo (for language), Tinker cad (for design), and skill-based apps for mechanics or electronics.
5. **Cloud Computing**. It enables storage, access, and sharing of educational resources and tools anytime and anywhere. Examples are: Google Drive, Microsoft OneDrive, and Dropbox.
6. **Artificial Intelligence (AI) and Machine Learning**. AI-powered tutors, adaptive learning platforms, and competency tracking systems. It provides personalized feedback and skill assessments.
7. **Internet of Things (IoT)**. They are smart devices and connected systems used in vocational fields like agriculture (smart farming), automotive technology, and industrial automation. They enable real-time monitoring and hands-on training with smart tools.
8. **Multimedia and Digital Content Tools**. These are videos, animations, 3D models, and interactive e-books. They enhance understanding of complex concepts and skills.
9. **Collaborative and Communication Tools**. Platforms like Zoom, Microsoft Teams, and Slack. They facilitate remote teaching, peer learning, and collaboration between institutions and industries.
10. **Digital Fabrication Tools**. Technologies such as 3D printing, CNC machines, and robotics. They provide hands-on training in design, prototyping, and manufacturing.

Roles of VTE in Economic Development

1. Development of Skilled Workforce

Vocational and Technical Education (VTE) is vital in building a skilled workforce that drives productivity, fosters technological progress, and stimulates economic growth. VTE plays a key role in "improving the technical competence of citizens, thereby promoting national development. A nation's growth is closely linked to the quality of its skilled manpower, which can be attained through effective vocational and technical education.

2. Employment Generation and Poverty Reduction

Vocational education plays a vital role in tackling unemployment by equipping learners with practical skills that enhance employability and foster self-reliance. According to Amoor and Aliyu (2014), VTE creates avenues for self-employment, thereby easing pressure on the formal labor market and contributing to poverty reduction. They further note that *Technical and Vocational Education and Training (TVET) has the potential to curb unemployment and underemployment, especially among young people, by imparting skills necessary for entrepreneurship and income-generating ventures.*

3. **Industrial and Technological Development**
VTE fosters innovation and supports industrial growth by supplying industries with skilled technicians and artisans. Okoye and Okwelle (2013) emphasize that the industrial sector cannot thrive without a strong VTE foundation, as it supplies the workforce required to operate and maintain modern technologies. *"Industrial and technological development depends largely on the availability of competent technical manpower, which is a product of an effective technical and vocational education system" (*Okoye & Okwelle, 2013,).

4. Economic Diversification
In countries dependent on a limited number of economic sectors (e.g., oil in Nigeria), VTE can support diversification by developing human capital for other sectors like agriculture, ICT, and manufacturing. *"TVET (Technical Education and Training) is essential for economic diversification and resilience, especially in resource-dependent economies"* (UNESCO, 2015).

Benefits of incorporating digital technology in vocational and technical education
1. E**nhanced Learning Experience: -** Digital tools like simulations, virtual labs, and interactive software allow students to practice skills in a safe, controlled environment, making learning more engaging and hands-on.
2. Access to Up-to-Date Information: - Digital technology provides instant access to the latest industry standards, techniques, and resources, ensuring students learn current practices.

3. Improved Collaboration: -Digital communication tools enable students and instructors to collaborate remotely, share projects, and get feedback quickly.

4. Cost-Effectiveness: - Virtual simulations can reduce the need for expensive physical materials and equipment, lowering training costs.

5. Skill Development for the Digital Economy: - Integrating digital tools helps students become proficient in technologies widely used in modern workplaces, preparing them better for jobs.

Challenges of digital technology in VTE

1. **Availability & Utilization**: Tools may exist but are not always used effectively (or at all) due to lack of infrastructure, lack of training, or other constraints. eg the study on availability & utilization of digital tools for TVET interactive learning in Universities in South-East Nigeria found very low availability and utilization.
2. **Teacher Competency / Pedagogical Readiness**: Even when tools are available, teachers may not have sufficient pedagogical/technical skills to effectively integrate them. Eg., TPACK model studies; training needed.
3. **Practical / Hands-on Components**: Vocational training often requires practical, workshop, or lab components which are difficult to replicate entirely via digital tools. Virtual labs/VR can help, but there are concerns about fidelity, cost, etc.
4. **Cost, Access & Equity**: Digital access (internet, devices) can be limited especially in rural or underfunded contexts.
5. **Sustainability / Maintenance**: Keeping digital tools updated, functional, supported over time can be challenging.

Need for Transformation: Why Traditional VTE Systems Are Insufficient in Today's Digital Economy
1. Mismatch Between Training and Industry Needs
Traditional VTE systems are often based on outdated curricula and teaching methods that do not align with the rapidly changing demands of the modern labor market. The skills taught in many VTE

institutions are no longer sufficient for industries driven by automation, artificial intelligence, and digital platforms. *Many VTE systems in developing countries still operate with outdated equipment and pedagogical approaches, resulting in a significant mismatch between graduates' skills and industry expectations"* (Maclean & Wilson, 2009,).

2. Limited Integration of Digital Skills

The rise of the digital economy has created a demand for new competencies such as digital literacy, data analysis, coding, cybersecurity, and the use of emerging technologies. Traditional VTE does not adequately prepare learners for this shift. *"TVET must respond to the digital transformation by embedding 21st-century skills, including ICT proficiency, adaptability, and problem-solving, to remain relevant"* (UNESCO, 2021,).

3. Inflexible and Rigid Structures

Conventional VTE systems are often inflexible, with fixed training schedules, long program durations, and limited options for modular or online learning. This makes it difficult to accommodate the needs of working adults, informal sector workers, or those requiring quick upskilling. *"Traditional vocational education lacks the flexibility needed to provide lifelong learning pathways in a rapidly changing digital world"* (European Training Foundation [ETF], 2020,).

4. Low Attractiveness and Poor Social Perception

In many societies, traditional VTE is seen as a second-tier option for students who are academically weak. This perception limits enrollment and investment in the sector, and hinders its evolution. *"TVET suffers from an image problem and is often viewed as a less prestigious path, discouraging both students and teachers from engaging with it meaningfully"* (Okolie et al., 2020,).

5. Inadequate Use of Technology in Teaching and Learning

Traditional VTE often relies heavily on face-to-face, teacher-centered approaches, with minimal use of digital tools such as simulations, virtual labs, or e-learning platforms. This limits the scalability, engagement, and personalization of training. *"The use of digital tools in technical education remains minimal, despite their potential to transform learning environments and outcomes"* (ILO, 2020,).

6. Lack of Teacher Capacity for Digital Instruction

Many instructors in traditional VTE systems are not trained in the use of digital technologies, e-learning platforms, or modern pedagogical strategies, limiting their ability to deliver relevant, tech-enhanced instruction. *"One of the major challenges in transitioning to digital VTE is the lack of digital competencies among teachers and trainers"* (UNEVOC, 2020,).

Purposes of Digital Technologies in Transforming VTE

1. Aligning VTE with Evolving Work & Industry Needs: Digital transformation in TVET is driven in large part by the challenges posed by Industry 4.0 and Industry 5.0: changes in job profiles, automation, AI, the digital economy, and so on. Digital technologies are needed so that VTE institutions can train, up-skill, and re-skill workforce members to meet those evolving demands. *Parua & Yang (2024)* discuss how primary drivers (Industry 4.0/5.0 and enabling digital technologies) cascade into secondary and tertiary drivers (digital economy, digital society, employment changes) that shape the transformation.

2. Pedagogical Innovation Improvement: Digital technologies enable shifts in how teachers teach and how students learn: moving from teacher-centered and lecture-based models to more active, experiential, simulation-based, and blended learning; they also facilitate personalized learning, feedback, and flexibility. For example, *Nataliia Dolgova (Pan & Filippova, 2025)* studied engineering educators in TVET and found that virtual labs, simulations, and AR/VR increase engagement and enhance skill development.

3. Expanding Access & Flexibility: Digital technologies allow more learners to access TVET training — including those in remote or underserved areas — and enable flexible modes of learning (online, blended, mobile) so that people who are working or have other time constraints can participate. This

helps lifelong learning. UNESCO-UNEVOC states that ICT in TVET is a key tool for universal access and helping all citizens gain the knowledge, skills, and attitudes necessary for living and working in a technology-driven environment.

4. Enhancing Skill Acquisition & Digital Literacy: As the economy becomes more digital, learners must acquire not just trade-specific technical skills but also digital skills, problem-solving, adaptability, ICT competence, etc. Digital technologies help deliver this kind of training (e.g., via simulations, digital tools, virtual labs). *Omutange, Mutai & Barasa (2025)* in Kenya found that the integration of modern digital technology platforms had a positive impact on learning outcomes in TVET settings.

5. Improving Employability: The integration of digital technologies in education ultimately seeks to enhance graduate employability by providing them with relevant skills, competencies, and adaptability demanded by today's employers. Closing the digital skills gap also ensures that graduates remain competitive in a labour market increasingly driven by digital tools. For instance, Awodiji and Magogodi (2022, 2023) highlight those soft skills—especially important in digital and hybrid work environments—play a significant role in boosting the employability of TVET graduates in Botswana.

6. **Bridging the Digital Divide**: In many developing contexts, disparities in access to digital infrastructure, reliable electricity, devices, and internet connectivity persist. Digital tools therefore serve not only as channels for content delivery but also as mechanisms to reduce inequalities in access to quality technical education. Niwamanya, Zhong, Matola, and colleagues (2025) explore how enterprise partnerships with TVET institutions can be strategically leveraged to mitigate these digital divides

Recommendations

Based on this review, the researcher recommends and highlights future research needs such as long-term impact assessments, cost–benefit studies, and investigations into emerging innovations like artificial intelligence and immersive virtual environments to further improve the effectiveness and scalability of VTE across varied socio-economic settings. For policy makers and the government, they should develop policies that promote the integration of digital technologies in VTE, provide grants, subsidies, or tax incentives to institutions adopting innovative digital training tools. Finally, governments should encourage open-source and low-cost digital solutions for long-term sustainability and regularly review and update digital tools to keep pace with technological changes in industry.

Conclusion

The adoption of digital technologies in Vocational and Technical Education (VTE) has emerged as a driving force for transformation, revolutionizing how skills are delivered, developed, and utilized in today's workforce. Innovations such as augmented and virtual reality, simulation tools, e-learning platforms, and smart devices have improved hands-on training, expanded learning opportunities, and increased the efficiency of knowledge transfer. By aligning traditional instructional approaches with the needs of the digital economy, these technologies will enhance the relevance of VTE and play a vital role in fostering sustainable economic growth. Nonetheless, realizing the full potential of this transformation requires stronger investment in infrastructure, capacity building for educators, and supportive policy frameworks.

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