Digital Transformation in Global TVET

Methodology and Practices

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Methodology and Practices

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2024

Published in 2024 by the UNESCO Chair on Digitalization in TVET,
Shenzhen Polytechnic University, China.
Website: https://unescoplatforms.szpu.edu.cn/

Suggested citation:
Yang, X., & Yang, W. (Eds.). (2024). *Digital Transformation in Global TVET: Methodology and Practices*. UNESCO Chair on Digitalization in TVET.

Preface

Over the past few decades, we have traversed multiple digital revolutions. These include the advent and proliferation of personal computers, the expansion of the Internet, the ubiquity of mobile communications, and the emergence of artificial intelligence (AI). Each revolution has heralded transformative shifts, redefining the boundaries of human knowledge and capabilities. Currently, we are on the cusp of the latest wave of the digital revolution, primarily driven by generative AI and other disruptive digital technologies. The current wave is distinguished from its predecessors by its speed, magnitude, and profound implications.

This revolution presents significant challenges, particularly in the realm of work. Technological advancements are creating new jobs at an unprecedented rate while making many others obsolete. Today's youth and adults, educated under traditional paradigms, often lack the digital and transversal skills required in modern professional environments. The knowledge and skills acquired in school quickly become outdated in the face of rapidly evolving technological and industrial landscapes. The mismatch of skills, combined with a global increase in youth unemployment, underscores the urgency of recalibrating our Technical and Vocational Education and Training (TVET) system to meet the demands of the digital age.

The TVET sector, a key driver of educational success and workforce readiness, is central to this transformation. The *UNESCO Medium-Term Strategy (2022–2029)* emphasizes capacity building for digital transformation as a strategic objective and outcome of the 2030 Agenda for Sustainable Development. The *UNESCO Strategy for TVET (2022–2029)* further reinforces the actions taken by TVET systems to reorient education and training towards future jobs by leveraging digital technologies. The way TVET engages with and harnesses the potential of digital transformation will

significantly influence our collective ability to achieve the Sustainable Development Goals and drive inclusive and equitable transitions.

In China, TVET is a critical component of the country's vision of building a Digital China. As the country strives for comprehensive integration of digital technologies across all sectors, including agriculture, manufacturing, finance, education, healthcare, transportation, and energy digital capacity building through TVET becomes increasingly crucial. However, we must acknowledge that digital transformation in TVET is a complex and challenging process. As Chen Ziji, the former Director of the Department of Vocational and Adult Education of the Ministry of Education, noted, 'Digitalization in TVET is not merely a technical issue or a simple overlay of digitalization and education; rather, it is a holistic and system-wide transformation that essentially reconstructs the TVET ecosystem'.

Against this backdrop, I am pleased to introduce this publication, *Digital Transformation in Global TVET: Methodology and Practices*. This report is a testament to our commitment as the UNESCO Chair on Digitalization in TVET to contribute to and disseminate knowledge on digital transformation and emerging technologies for global TVET communities. The report serves as a guidebook that demystifies the methodologies for digital transformation and breaks it down into manageable and actionable steps for TVET leaders and educators. It analyzes digital transformation in TVET systematically, covering theoretical underpinnings, governance modes, programmes and curricula, use of technologies, essential competencies, international cooperation, and emerging challenges. In each domain, this report can serve as a resource book, illustrating the best practices currently employed at Shenzhen Polytechnic University and our partner institutions and enterprises worldwide.

I hope that this report will ignite discussions and inspire actions in the changing landscape of the digital era. By actively engaging in and adapting to digital transformation, we can enhance the potential of TVET systems in societies, bridge the skills gap, and empower our younger generations and all workers to be resilient and prepared for the future, thereby promoting global sustainable development.

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Introduction

Wenming Yang

In an era marked by the swift emergence of digital technologies and innovative breakthroughs, the urgent need for digital transformation is palpable across all societal sectors. As digital transformation currents profoundly reshape the global educational landscape, Technical and Vocational Education and Training (TVET) institutions find themselves at the heart of this shift. The convergence of technological advancements, the rise of new industries, and the subsequent evolution of the world of work necessitate a robust response, particularly from TVET sectors. Given that TVET institutions aim to equip learners with practical skills and knowledge aligned with labour market demands, they play a crucial role in bridging the skills gap often created by digital revolutions.

To date, the speed of this digital shift has surpassed our understanding. Evidence-based strategies for TVET governance and leadership, pedagogical and curricular design, and quality assurance in the digital era require substantial research focus. Moreover, the vital aspect of international cooperation and knowledge transfer in driving a resilient and inclusive digital transformation in TVET remains largely unexplored and mis-understood. This highlights the relevance and significance of the current report, *Digital Transformation in Global TVET: Methodology and Practices*. The report aims to address these gaps, offering a comprehensive perspective on the phenomenon's various aspects, supplemented by examples of promising practices. Accordingly, it seeks to provide references for TVET leaders, educators, and policymakers in planning and implementing

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digital transformation and stimulate dialogue and further investigation into this critical educational area.

Chapter 1 of this report establishes the context of digital transformation in society, specifically in TVET. It introduces significant shifts in the technological, economic, and societal landscapes, primarily through the lens of Industry 5.0 and its cyber-physical fabric. The chapter analyzes the profound impacts these changes foreshadow for the future world of work and the required competencies, as well as global and regional strategic responses to these transformative forces. The chapter then evaluates the current state of TVET, noting that while strategies abound, actionable execution at the ground level remains scarce. This disconnect between policy frameworks and their practical applications has highlighted the need for a TVET system that not only incorporates technology but also redefines pedagogical approaches to cultivate a digitally fluent workforce. Against this backdrop, the end of Chapter 1 poses the central research question to be explored in this report: How can TVET institutions effectively plan and implement digital transformation to meet the evolving demands of the digital era?

Chapter 2 delves into the theoretical underpinnings and strategies for planning digital transformation in TVET. It starts by elucidating the intricate meanings of 'digital transformation' and the various stages of the process. The chapter subsequently reviews several major perspectives to comprehend the nature of digital transformation, including the social evolution perspective, the technology-centric perspective, the actor-centric perspective, the ecosystem perspective, and connectivism. Despite their different focuses, these perspectives underscore that digital transformation is an all-encompassing process involving technology, culture, and complex social relations and mechanisms. Drawing from existing frameworks for digital transformation in higher education and corporate contexts, this chapter proposes a framework for digital transformation in TVET. The framework illustrates that digital transformation in TVET is a response to two pivotal changes in industry and society: the industrialization of digital technologies and the digital transformation of traditional industries. These developments impact the domains of economy, society, governance, and the environment, which subsequently affect the world of work and necessitate a corresponding transformation in TVET institutions. This framework also introduces practical approaches for implementing digital transformation in TVET, which are further explored in the subsequent chapters.

Chapter 3 centres on the digital transformation of TVET governance. It commences by highlighting the guiding role of international, regional, and national strategies that shape this transformation. The chapter offers insights into how international organizations underscore the importance of digital technologies in enhancing the quality, accessibility, and flexibility of education. It also discusses the policies and initiatives of regional organizations and national governments to align the education system with digital advancements. The chapter further investigates the frameworks, mechanisms, and steps crucial for steering TVET's digital transformation, focusing on governance entities from the macro to the micro level. It outlines comprehensive steps and stages for developing and implementing digital transformation strategies within TVET governance and introduces a maturity framework to assess an organization's level of transformation. Subsequently, the chapter scrutinizes the TVET ecosystem and its various models in the context of digital transformation. It analyzes the stakeholders within the ecosystem, as well as diverse TVET models and their relevance to the digital shift. Lastly, the chapter acknowledges the need for TVET reform to mirror broader economic, social, and political contexts and presents a governance framework comprising six questions to aid policymakers, educational institutions, and stakeholders in addressing the opportunities and challenges within the digital age.

Chapter 4 focuses on the digital transformation of TVET programmes and curricula. It provides an in-depth analysis of the evolution of academic frameworks within TVET institutions in response to a progressively digitalized educational landscape. The chapter scrutinizes the catalysts for this transformation, strategic implementations, and the supportive measures necessary for effectively executing the digital shift in programmes and curricula. It pinpoints key changes within TVET programmes, emphasizing the need for multi-skilled professionals capable of excelling in various employment domains, and the significance of interdisciplinary approaches in modern TVET. The chapter presents a framework that illustrates the digital transformation of TVET programmes through the collaboration of macro-, meso-, and micro-level institutions. It highlights several innovative methods to facilitate this transformation, such as the establishment of digital ecosystems, virtual simulation training centres, virtual teaching and research centres, programme teaching and learning databanks, and e-learning platforms. Furthermore, this chapter outlines the integral roles different stakeholders play in the digital transformation of TVET curricula and introduces various approaches to digitally transforming TVET

curricula. These include integrating digital knowledge and skills, blending learning techniques, and advancing collaborative learning tools to maintain curriculum relevance and competitiveness in a digital economy.

Chapter 5 delves into various digital technologies applied to TVET and their transformative impact on TVET pedagogy. The chapter commences by delineating key infrastructure elements, including hardware facilities (computers and tablets, virtual reality devices, and high-speed network connectivity), software support (learning platforms, educational management systems, and online assessment systems), digital teaching environments (multimedia classrooms, smart classrooms, and virtual simulation training centres), and digital security measures. Additionally, the chapter discusses the growing relevance of ubiquitous computing, collaboration technologies, artificial intelligence (AI), extended reality technologies, and blockchain technology in enhancing TVET. The chapter introduces innovative digital pedagogies, such as blended learning, simulation-based learning, game-based learning, flipped classrooms, and precision teaching—each offering unique advantages in practical skill development. The challenges in integrating these digital pedagogies are also examined, highlighting issues such as instructional design, the need for substantial investments in infrastructure, and demands on teacher development for pedagogical innovation. Finally, the chapter addresses the burgeoning influence and potential of Open Educational Resources (OERs) in propelling the digital transformation of TVET.

Chapter 6 delves into the crucial aspect of capacity building for digital transformation in TVET, with a focus on three primary stakeholders: leaders, teachers, and students. The chapter commences by defining digital transformation leadership, underscoring the pivotal role leaders play in steering the transformation process within TVET institutions. It delineates eight distinct roles that a digital transformation leader should embody, spanning from strategy formation to fostering a digital culture within the organization. Subsequently, the chapter presents the frameworks designed by UNESCO-UNEVOC and the UNESCO Chair on Digitalization in TVET, illustrating pathways for developing TVET leaders' competence for digital transformation. The focus then shifts to the anticipated capacities of TVET teachers, detailing the competences vital for adapting and delivering a curriculum relevant to a technologically evolving society. The chapter refers to various global digital competency frameworks to outline expectations for teachers, emphasizing strategies for transforming pedagogical approaches in response

to the digital age. For TVET students, digital competences are underscored as a cornerstone for success, both as civic participants in a digital society and as future contributors to the workforce. The chapter examines several digital competence frameworks applicable to broad individual development, highlighting the importance of equipping students with digital proficiencies.

Chapter 7 investigates the necessity of international collaboration and exchange in augmenting the digital transformation of TVET. It introduces the primary approaches to strengthening international collaboration, which include collaboration agreements, resource sharing, international events for dialogue, cross-national projects to stimulate creativity in TVET, and collaborative research that informs stakeholders globally. The chapter then presents major international platforms and partnerships, particularly those initiated by UNESCO and UNESCO-UNEVOC, to promote digital transformation in TVET. It also introduces typical programmes of international collaboration serving this purpose, such as those initiated by the Global Education Coalition, the Global Skills Academy, and the UNEVOC Network. These programmes are instrumental in transferring digital transformation expertise, fostering skills development, and bridging education inequalities. Furthermore, the chapter emphasizes the importance of sharing tools, resources, and promising practices, signifying the broader collective commitment across institutions and borders to building a digitally empowered TVET system.

Lastly, Chapter 8 identifies the challenges in the digital transformation of TVET, such as insufficient funding for digital infrastructure, widening of the digital divide, skills mismatch, lack of institutional strategic planning, and the urgency to enhance the digital competences of TVET leaders and teachers. The chapter also outlines the emerging trends that are shaping the future of TVET. It discusses the transformative impact of AI on TVET, emerging learning modalities, the evolving role of TVET teachers from ‘dual-professional’ to ‘multi-professional’, increasing focus on students’ trans-versal skills and Science, Technology, Engineering, Arts, and Mathematics (STEAM), the potential of micro-credential programmes, and efforts made to facilitate international recognition of TVET qualifications. The chapter concludes with a set of recommendations, covering six focal areas, for enhancing the digital capacities of TVET institutions.

Complementing the concepts and approaches introduced in each chapter, this report also includes in the Appendix 10 cases of ‘promising practices’ drawn from global TVET sectors for the practical demonstration of effective digital transformation in TVET.

Collectively, this report forms a comprehensive guide for the foundations, methodology, and practices of digital transformation in TVET.

Chapter 1

Background of Digital Transformation in TVET

Xiuzhen Zeng and Zhuoya Zhong

This chapter provides an overview of the digital transformation in Technical and Vocational Education and Training (TVET). It explores the technological shift brought about by Industry 5.0, the expansion of the digital economy, and the development of a digital society. The implications of these changes on the future world of work and the evolving skill requirements are critically analyzed. Furthermore, this chapter addresses global strategies for digital transformation in TVET and the current state of TVET systems worldwide. Given these driving factors of digital transformation in TVET, the chapter identifies existing gaps and weaknesses in TVET and formulates the research question of this report.

1.1 Convergence of technology, economy, and society in digital transformation

1.1.1 Technological transformation of Industry 5.0

The industrial revolutions represent a sequence of significant socioeconomic and technological changes that took place during distinct historical periods, leading to

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substantial advancements across various global sectors. The most recent revolution is marked by the integration of digital technology, physical science, and biological systems, driving innovations at an unparalleled pace (Schwab, 2016). As a result, the digital transformation of TVET has emerged as an inevitable response to the challenges and opportunities posed by this technological upheaval.

The Technology Agility Index primarily evaluates a technology's potential to disrupt society, covering aspects such as the speed of technological development, transformation of industry structures, changes in unemployment rates, emergence of new markets, and improvements in productivity (Shen, 2023). From the First Industrial Revolution to the Fourth and the proposed Fifth Industrial Revolution (Industry 5.0), technological agility has consistently acted as a driving force and mutual catalyst for industrial evolution.

The First Industrial Revolution, which took place from approximately 1760 to 1840, marked the advent of steam power and mechanization. This period catalyzed the transition of agrarian societies into industrialized ones, mechanizing production, leading to urbanization and the emergence of factory-based economies (Culot et al., 2020; Schwab, 2016). The Second Industrial Revolution, spanning the late 19th century to the mid-20th century, was characterized by the widespread use of electricity and mass production techniques, significantly propelling the growth of modern industrial economies (Whang et al., 2022). The Third Industrial Revolution, emerging in the late 20th century, ushered in the era of digitalization and automation, profoundly altering communication and data processing paradigms (Schwab, 2016). The Fourth Industrial Revolution, or Industry 4.0, involves the integration of advanced technologies across various domains, leading to a profound reshaping of industries and societies in unprecedented ways. Characterized by the convergence of digital, physical, and biological systems, the 4IR has introduced a new era of automation, artificial intelligence (AI), and smart technologies, shaping industries and economies in innovative ways (Avis, 2020).

Industry 5.0 is not merely an extension of Industry 4.0 but a response to it, offering the prospect of continued technological innovation and economic development. It is anticipated to re-emphasize the role of humans within the industrial process, aiming to bring a more personalized, sustainable, and collaborative approach to the industry by merging human creativity and craftsmanship with the advanced capabilities of smart

machines and AI. In this context, emerging AI tools like ChatGPT have opened new avenues for content creation, communication, and learning within TVET. Furthermore, as technology continues to evolve and innovate, the educational sphere has seen the emergence of noteworthy and utilizable new educational technologies such as virtual reality (VR), augmented reality (AR), Learning Management Systems (LMS), and cloud computing, all of which merit attention and adoption.

1.1.2 Development of the digital economy

Gluckman (2018) posits that all technologies, whether existing or yet to be invented, carry both benefits and risks. Human history bears witness to the interplay of innovation, development, and the use of technology while mitigating its drawbacks. For example, during the stage of Traditional Society, economic growth was slow due to the limitations of the agricultural economy and basic production methods, resulting in relatively underdeveloped economy. This situation was transformed by the First Industrial Revolution, which introduced significant technological innovations such as mechanization and factory-based production, dramatically enhancing productivity and output (White & Scott, 2022). In the era of the digital economy, the increased fluidity of information and technology has made the digital economy more agile and efficient.

Data is fundamental to the development of the digital economy (CAICT, 2020). This process involves collecting, analyzing, and using data to create economic value, transforming data into useful information, insights, or products to enhance efficiency, develop new revenue streams, or strengthen existing business models. Digital industrialization and industrial digitalization are the two central pillars of the digital economy (CAICT, 2020). Digital industrialization focuses on the development of industries centred around digital technologies such as big data, cloud computing, AI, and IoT, which have become independent sectors driving new economic growth. Conversely, industrial digitalization involves the integration of information technology and the Internet into traditional manufacturing and service industries to enhance efficiency, reduce costs, and bolster competitiveness, representing the transformation and upgrading of traditional industries through the adoption of digital technologies.

The impetus of digital industrialization and industrial digitalization has led to profound changes in the labour market's skill demands. Consequently, this necessitates that the programmes and curricula of TVET, along with the strategic objectives for talent

cultivation within TVET, exhibit agility and a responsive alignment to the evolving demands brought forth by industrial digitalization and digital industrialization. This alignment is imperative to ensure the relevance and efficacy of TVET in an increasingly digitalized industrial landscape.

1.1.3 Development of the digital society

The rise of the digital economy has disrupted traditional industrial models, instigating a digital revolution that has led to significant societal changes and challenged various aspects of human behaviour and social systems, fundamentally altering how people live and work (Gluckman, 2018). While the industrial economy spurred urbanization and social structure changes, the digital economy has fostered a global Internet society.

The advent of the digital society has transformed social interactions, intertwining people's lives with digital technology. From smart devices to smart cities, digital technology has profoundly influenced people's interactions with the world. Notably, the Japanese government has introduced the concept of Society 5.0, envisioning a future society that seamlessly integrates advanced technologies with societal needs and challenges. This concept highlights the symbiotic progression of technology and humanity, aiming to create an intelligent, sustainable society capable of addressing societal issues while enhancing the quality of life (Cabinet Office, Government of Japan, n.d.).

In the digital society (Society 5.0), digital communication tools and social media have altered interaction modes among individuals, facilitating cross-temporal and cross-spatial interactions. The emergence of online communities has redefined social relationships (Nagy & Somosi, 2022). Concurrently, in the field of TVET, technological advancements have introduced more flexible and convenient learning modes. Online learning and blended learning have become prevalent, with increasing demand for flexibility in course start times, lengths, and formats. Students are showing a growing preference for online courses over face-to-face interactions, particularly hybrid and HyFlex courses (EDUCAUSE, 2023).

The traditional dichotomy between online and face-to-face learning is dissolving, as both teachers and students in TVET now experience multimodal teaching and learning within a single course—online and in person (EDUCAUSE, 2023). This transformation within the educational sector and the ensuing ambiguity of boundaries necessitate that

educators in TVET possess a comprehensive understanding of the information, knowledge, training, and skills pertinent to best teaching practices. Moreover, a holistic enhancement of their digital capacity is imperative. Such empowerment enables them to proficiently navigate multimodal teaching environments and ensures that all students have access to equitable and high-quality learning.

1.2 Evolution of skills and global strategies in TVET

1.2.1 Changes in skills needs in the future world of work

In the digital economy and society, technologies such as AI and robotics are transforming sectors and future jobs at an unprecedented pace. The development of AI is instigating changes 10 times faster and 300 times larger than previous industrial revolutions, with nearly 3,000 times the impact (Dobbs et al., 2016). AI technologies are displacing outdated jobs (Petropoulos, 2018). A study involving over 200,000 workers across 29 countries, including 27 from the OECD plus Singapore and Russia, estimated that the proportion of jobs to be replaced ranges from approximately 20–25% in Nordic countries and East Asia to over 40% in Eastern Europe by the early 2030s (PwC, 2018a). PwC (2018b) projected that in the next two decades, AI and other labour-saving technologies would displace 26% of current jobs in services, construction, industry, and agriculture in China, with the UK estimate at 20%. The scale of job replacement is even higher in the US, with Frey and Osbourne (2017) calculating that 47% of jobs in the US were at high risk of automation in the next two decades.

Conversely, digital technologies are also creating vast new areas of work, such as robotics, AI-enabled analytics, machine learning, and virtual personal assistance (Harvard Business Review, 2016). It is estimated to create 297 million future jobs in China between 2017 and 2037 (PwC, 2018b) while creating 20% of future jobs in the UK in the same period (PwC, 2018c).

As the digital economy becomes mainstream and the world of work undergoes rapid changes, there is an increasing need for skilling, upskilling, and reskilling in digital technologies. The International Labour Organization (ILO) predicted a general uplift in technical skills (Ernst et al., 2018). According to the ILO, the hours worked with technological skills will increase from 31 billion in 2016 to 60 billion in 2030 in the US, and from 41 to 60 in Western Europe (Ernst et al., 2018). This suggests that new entrants

to the labour market need skilling in related technologies for initial employment. In terms of upskilling, the McKinsey Global Survey reported that up to 87% of 1,216 surveyed employers worldwide identified skills gaps either currently or within the next five years, with data analytics and Information and Communication Technology (ICT) being the top two areas of skills gaps (McKinsey & Company, 2020). This implies that those employed must master more advanced digital skills for increasingly digitalized working environments, aligning with the implications of the European Training Foundation (Brolpito, 2018). Lastly, concerning reskilling, the World Economic Forum estimated that half of employees worldwide might need to change jobs and reskill by 2025 due to the obsolescence of their old jobs with the application of new technologies (Schwab & Zahidi, 2020). Li (2022) found that 'technology use, monitoring, and control' and 'technology design and programming' would be among the top 10 skills for reskilling and upskilling the future-ready workforce in 2025, which were not listed in 2015 and 2020. This highlights the importance of emerging digital skills in reskilling.

In addition to technological skills, the demand for transferable skills is rising due to the evolving landscape of future jobs. UNESCO (2022) recognizes that societies require not only digital and technological skills but also collaboration and civic competencies, creativity, social and emotional skills, and a sense of global solidarity. The European Commission (2018) concurs, suggesting that AI capacity building should consider not only specific skills but also key competences in science, technology, liberal arts, and citizenship. These transversal skills have always been crucial in the job market, as evidenced by Li's (2022) finding that skills such as 'complex problem solving' and 'critical thinking' consistently rank among the top 10 necessary job skills. Furthermore, these skills will be increasingly needed due to the application of digital technologies in emerging areas of work (Ernst et al., 2018).

1.2.2 Global strategies on digital transformation in TVET

The changing skills needs have drawn attention from global education and skills-development agencies, including UNESCO, the ILO, and the World Bank. Two of the United Nations' Sustainable Development Goals (SDGs)—SDG 4 'Quality Education' and SDG 8 'Decent Work and Economic Growth'—are particularly relevant to skills development and could influence the progress of all SDGs (United Nations, n.d.). Committed to the SDGs, UNESCO has developed the latest guiding strategy for TVET

transformation, *Transforming Technical and Vocational Education and Training for Successful and Just Transitions: UNESCO Strategy 2022-2029*. It identifies three priority areas for TVET and emphasizes skills for transitioning to digital economies (UNESCO, 2022). The ILO's *Strategy on Skills and Lifelong Learning 2030* suggests that learning programmes and pathways should support digital learning and digital skills delivery (ILO, 2023). Specifically, the ILO Skills Branch addresses the impacts of technologies on TVET and skills systems under the 'Digitalization of Skills Systems' section. Similarly, the World Bank's report (2023) argues that investing in digital technologies in TVET, such as VR training, could enhance the resilience of TVET systems.

At the regional level, strategies for digital transformation in TVET or skills development are also being developed. For example, the European Union's *New Skills Agenda for Europe* emphasizes the importance of digital skills in TVET and encourages member states to invest in digital infrastructure, promote digital literacy, and integrate digital technologies into curricula. Similar regional initiatives exist elsewhere, such as the African Union's *Continental Education Strategy for Africa*, which underscores the role of digital technologies in transforming TVET. The International Federation of Red Cross and Red Crescent Societies (IFRC) has released the *IFRC Strategic Framework on Education 2020–2030* to guide global Red Cross and Red Crescent Societies in education-related endeavours. It emphasizes the need to promote innovative educational methods and the application of digital technologies to enhance education quality, coverage, and accessibility (BRILL, 2015).

National strategies are being implemented to bridge the digital divide and ensure equitable access to digital resources and opportunities for all learners. These strategies include initiatives to provide Internet connectivity, affordable devices, and digital literacy training to marginalized communities. For instance, Singapore's 'SkillsFuture Movement', implemented in 2015, supports adult and vocational learners in acquiring skills and digital literacy through scholarships, subsidies, and training programmes to enhance learners' digital competencies (SkillsFuture, 2015). In 2022, the Chinese Government issued the policy document *Key Work on Improving Digital Literacy and Skills for All*. This document encourages the provision of digital resources, the improvement of digital skills for work and life, and the ethical use of data, providing guidance for the transformation of TVET (Chinese Government, 2022).

1.3 Current status of global TVET

The digital evolution in technology, the economy, and society acts as an **external driver**, irreversibly directing the digital transformation of TVET. This transformation necessitates the development of a workforce capable of adapting to rapid digital changes and meeting the dynamic skill requirements of the market. Within the TVET domain, the digital transformation of technology calls for a parallel transformation in TVET pedagogy and Educational Technology (EdTech). The economy's shift towards digital transformation demands a corresponding revision of programmes and curricula for talent development. Furthermore, as society transitions towards a digital communication era, digital transformation requires innovative digital education scenarios.

While numerous TVET strategies have been proposed at a **macro level** to guide this transformation for governance, a significant discrepancy exists at the **practical implementation level**. The TVET sector currently faces deficiencies in several areas: digital governance, enhancement of educators' digital capacities, development of digital infrastructure, digital transformation of programmes and curricula to address industrial digitalization and digital industrialization, and agility in collaborating with the market to meet the skill demands of a digital transformation.

These deficiencies indicate that TVET must move beyond traditional approaches. Persisting with outdated methodologies is not only ineffective but also widens the existing skills gap, leaving students ill-equipped for the modern workforce. Therefore, TVET must proactively embrace innovation and pursue development, with a significant pathway being the comprehensive adoption of digital transformation. This transformation is not merely about integrating technology; it involves fundamentally rethinking how education is delivered, with a specific focus on equipping students with essential digital skills. Concurrently, the evolution of educational theories, particularly the emergence of connectivism, has heralded a new era. This paradigm shift underscores the need for TVET to not only impart knowledge but also to build expansive digital learning networks using advanced educational technologies. This shift aims to empower students with the ability to engage in precise, effective, and self-directed learning, thereby preparing them to be adaptable professionals and lifelong learners in an increasingly digital world.

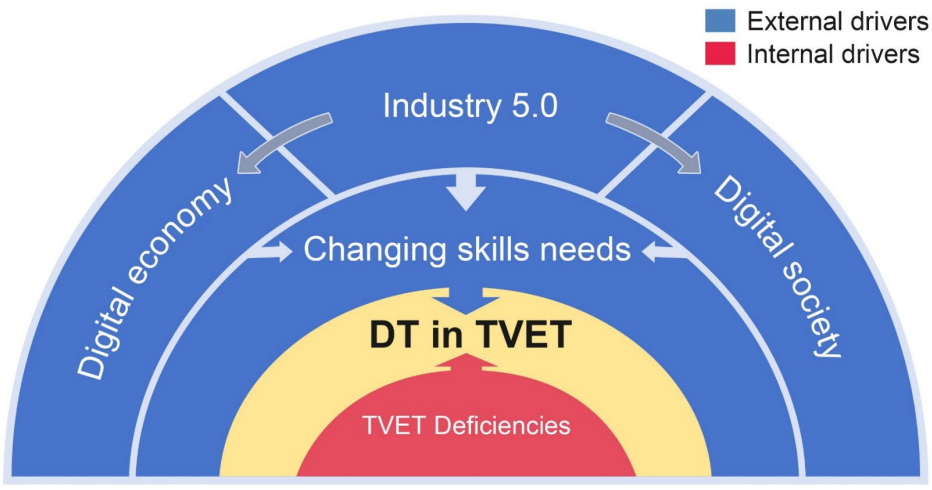
Therefore, the benefits derived from addressing these deficiencies through digital transformation inadvertently serve as **internal drivers**, further propelling the necessity for TVET's digital transformation—a shift that is both irreversible and imperative.

However, ambiguity still prevails within the TVET ecosystem regarding the essence of digital transformation, its objectives, and the methodologies for its implementation. The lack of clear solutions at the **practical level** indicates a pressing need for delineating the 'how' and 'what' of digital transformation in TVET. This necessitates a definitive exploration and elucidation of the practices and paths forward in TVET's journey towards a digitally empowered future.

1.4 Research question

External drivers propelling the digital transformation of TVET encompass technological, social, and economic transitions. These drivers necessitate a critical examination of the current gaps in TVET's governance, programmes, curricula, and pedagogy in response to industrial digitalization and digital industrialization, as well as the deficiency in market-responsive agile collaboration. These shortcomings not only underscore the urgent need for digital transformation but also inherently act as internal drivers, prompting TVET's self-innovation and adaptation to future changes. Figure 1.1 illustrates the relationships between the external and internal factors driving digital transformation in TVET. In this context, the present report focuses on the research question: **How can TVET institutions effectively plan and implement digital transformation to meet the evolving demands of the digital era?** Subsequent chapters will address this research question from various perspectives.

Figure 1.1 External and internal drivers of digital transformation of TVET



Source: Authors.

1.5 Summary

This chapter provides an overview of the background of digital transformation in TVET. It highlights the pivotal role of Industry 5.0 as a catalyst for digital transformation in TVET, prompting a fundamental rethinking of skills and instructional methods. The emergence of a digital economy and society further accelerates this transformation, emphasizing the importance of digital literacy and innovative learning approaches to align with the new economic landscape.

The dynamic nature of future skills within the job market is a pressing consideration, underscoring the critical importance of digital competencies. Consequently, skilling, upskilling, and reskilling become essential components in TVET, ensuring the workforce remains adept and responsive to technological shifts. Recognizing the need for a strategic approach, international frameworks are reinforcing the push towards digitization in TVET to secure sustainable economic growth.

Nevertheless, the urgency for change is unmistakable, as current TVET systems exhibit deficiencies that require attention to keep pace with emerging challenges and market demands. In addressing these needs, the chapter presents the research question of the report: How can TVET institutions effectively plan and implement digital transformation to meet the evolving demands of the digital era? This inquiry aims to explore effective solutions for digital transformation in TVET.

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Chapter 2

Methodology for Digital Transformation in TVET

Wenxi Wu and Wenming Yang

This chapter overviews the methodology for digital transformation in Technical and Vocational Education and Training (TVET). It starts by outlining the definitions and stages of 'digital transformation', thereby establishing a clear understanding of the concept. The chapter then explores various theoretical perspectives that situate digital transformation within the broader spectrum of evolving trends. After reviewing existing models of digital transformation in the business sector and higher education, the chapter narrows its focus to TVET. It provides a comprehensive definition of digital transformation in TVET and explains the rationale behind this process. Lastly, the chapter proposes a framework to guide TVET institutions in the systematic implementation of digital transformation strategies.

2.1 Definitions of digital transformation

Digital transformation is a crucial and strategic process for contemporary organizations, which must innovate to prosper in an increasingly digital environment. The discourse surrounding 'digital transformation' is highly dynamic today, and the term has evolved into a catch-all phrase that assumes various meanings depending on the context and

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perspective. It is vital for leaders and practitioners across all fields, including TVET, to have a clear understanding of the meaning and nature of digital transformation. This understanding will serve as a foundation for effectively implementing digital transformation initiatives that align with the goals of different sectors.

Numerous definitions of 'digital transformation' have been provided by national and international authorities, business practitioners, and researchers. Table 2.1 presents some examples. Some definitions emphasize the application of digital transformation in a business context, focusing on enhancing customer experience, operational processes, and business models. Others concentrate on the broader economic and societal impact, adopting a more neutral and holistic view.

Table 2.1 Selected definitions of 'digital transformation'

Source	Definition
OECD (2019)	Digital transformation refers to the economic and societal effects of digitization and digitalization. Digitization is the conversion of analogue data and processes into a machine-readable format. Digitalization is the use of digital technologies and data as well as their interconnection which results in new or changes to existing activities.
Kane (2017), *MIT Sloan Management Review*	Digital transformation is about how technology changes the conditions under which business is done, in ways that change the expectations of customers, partners, and employees.
McKinsey & Co. (2023)	Digital transformation is the rewiring of an organization, with the goal of creating value by continuously deploying tech at scale.
Morakanyane et al. (2017, p. 437), definition based on systematic literature review	Digital transformation is an evolutionary process that leverages digital capabilities and technologies to enable business models, operational processes and customer experiences to create value.
Mergel et al. (2019, p. 12), definition based on expert interviews	Digital transformation is a holistic effort to revise core processes and services of government beyond the traditional digitization efforts. It evolves along a continuum of transition from analogue to digital to a full stack review of policies, current processes, and user needs and results in a complete revision of the existing and the creation of new digital services. The outcome of digital transformation efforts focuses among others on the satisfaction of user

	needs, new forms of service delivery, and the expansion of the user base.
Gong and Ribiere (2021, p. 12), definition based on systematic literature review	Digital transformation is a fundamental change process, enabled by the innovative use of digital technologies, accompanied by the strategic leverage of key resources and capabilities, aiming to radically improve an entity and redefine its value proposition for its stakeholders.
Brooks and McCormack (2020, p. 5), definition with a focus on higher education	Digital transformation is a series of deep and coordinated culture, workforce, and technology shifts that enable new educational and operating models and transform an institution's operations, strategic directions, and value proposition.

According to these definitions, digital transformation is a significant, comprehensive change resulting from the adoption of digital technologies and the strategic integration of digital practices, tools, and platforms. It extends beyond the mere implementation of new digital tools and involves rethinking existing business models, processes, and strategies with a defined digital focus. In essence, digital transformation revolves around several key elements:

- **Use of digital technologies:** All definitions underscore the role of digital technologies in catalyzing transformation across various sectors. Technologies such as cloud computing, big data analytics, the Internet of Things (IoT), artificial intelligence (AI), and blockchain propel digital transformation. They do so by enabling data-driven decision-making, enhancing experiences for customers and employees, improving operational processes, and fostering a culture of innovation.
- **People-centric approach:** Although technology is the catalyst for digital transformation, it should ultimately centre around people. This approach involves considering the impact of technology on those within the organization and ensuring that the changes implemented are beneficial to the people involved. Arguably, digital transformation is less about technology itself and more about talent, leadership, and management, who must possess the necessary skills to make technology useful and relevant (e.g. Abbu et al., 2022). Furthermore, digital transformation necessitates continuous alignment with rapidly evolving customer needs and expectations in the digital age. Without this alignment, even the most advanced technology may remain underutilized.

- **Change in behaviour:** A recurring theme in these definitions is the concept of change or 'transformation' in existing processes, operational structures, business models, and customer experiences. This change is not merely superficial but involves a fundamental restructuring or radical improvement that redefines an entity's value proposition for all stakeholders. It also necessitates a cultural shift within the organization, which could involve promoting a culture of innovation, adaptability, and continuous learning.
- **Generation of value:** Digital transformation aims to create, improve, or deliver value. This includes value for businesses in terms of operational efficiency and commercial success, value for governments in terms of service delivery and user satisfaction, and value for society at large in terms of economic and societal impact.

In this report, a working definition of digital transformation can be summarized as a comprehensive and strategic process where organizations integrate digital technologies into all aspects of their operations to enhance digital awareness, management, competencies, and outcomes. This process involves a continuous commitment to change that aligns with the evolving expectations and demands of stakeholders and society at large.

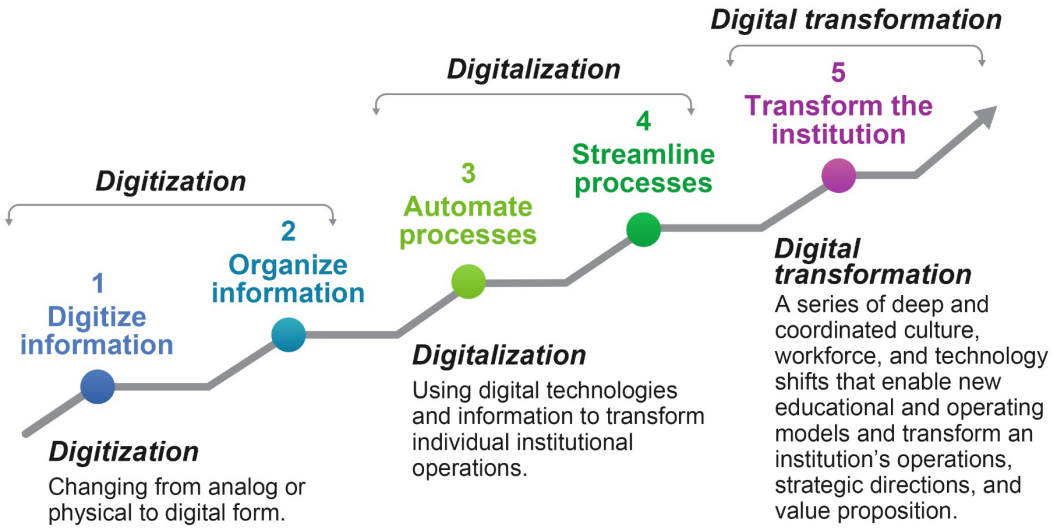
2.2 Stages of digital transformation

Many scholars and business experts have highlighted three distinct yet interconnected aspects of digital evolution: *digitization, digitalization*, and *digital transformation*, often referred to as 'the three Ds' (Bloomberg, 2018; Gong & Ribiere, 2023; Reinitz, 2020). These terms represent sequential stages in an organization's digital maturation, as depicted in Figure 2.1.

The first stage, **digitization**, refers to the conversion of analogue information into a digital format that can be stored, processed, and transmitted by computers. The second, **digitalization**, involves the use of digital technologies to optimize business processes, enhance or innovate services, and enable new capabilities. An example of digitalization is businesses utilizing online platforms and social media channels for product marketing and reaching potential customers globally. The third, **digital transformation**, encompasses both digitization and digitalization but extends beyond these two. It is a comprehensive change that involves using digital technologies, such as big data, cloud

computing, IoT, AI, and blockchain, to alter or create new business models, culture, and customer experiences to meet changing market demands. Essentially, digital transformation is not merely about updating technology or processes; it signifies a paradigm shift in the organization's culture, operations, and the way it delivers value to its customers. This may involve exploring new business models, entering new markets, or even pioneering new digital-led approaches to problem solving. Ultimately, it is about being agile, adaptable, and consistently customer-focused in a constantly evolving digital world.

Figure 2.1 Stages of digital transformation



Source: Brooks and McCormack (2020, p. 5).

2.3 Theoretical perspectives on digital transformation

2.3.1 Social evolution perspective

The theoretical trajectory of digital transformation can be situated within the framework of social evolution, which encompasses a symbiotic enhancement of socio-technical systems. Drawing on the Social Shaping of Technology theory, which asserts that social factors critically influence technological development (Williams & Edge, 1996), digital transformation is perceived as an interdependent outcome of societal evolution and technological innovation. The progression from Industry 1.0 to the anticipated emergence

of Industry 5.0 consolidates this theoretical standpoint, illuminating the intertwined advancement of human competencies and machine capabilities (Schwab, 2017).

Industry 1.0 initiated mechanization through water and steam power, transitioning to mass production catalyzed by electrical power in Industry 2.0. This transition manifested a transformative societal shift aligning with technological affordances. Industry 3.0 marked an era where electronics and information technology became the catalysts of automation, aligning with Castells' (1996) concept of the rise of the 'network society', leading to a digitized, globalized, and knowledge-intensive socioeconomic order. Conversely, Industry 4.0 extends beyond the automation ethos to establish cyber-physical systems, characterized by interconnectivity, cognitive computing, and smart networks, firmly rooted in the Fourth Industrial Revolution framework (Kagermann, Wahlster, & Helbig, 2013). The anticipation of Industry 5.0 signals a 'coopetition' between human ingenuity and AI, advocating for an inclusive, sustainable, and human-centric production paradigm (European Commission, 2021). This potential era is conceptualized within the theory of socio-technical systems, where the reciprocal feedback loop between society and technology fosters emergent, holistic industry models (Trist, 1981).

Parallel to the stages of industrial evolution, the transition from Society 1.0 to Society 5.0 provides a context for understanding digital transformation. Society 1.0, also known as the Hunting Society, was the earliest form of human social organization. Society 2.0, or the Agricultural Society, was rooted in farming and the cultivation of crops, marking the beginning of settled human communities. Transitioning to Society 3.0, the Industrial Society emerged with the onset of industrialization. This era was distinguished by refined industrial processes and the creation of urban centres, which led to increased economic complexity and the diversification of social roles. Society 4.0, known as the Information Society, heralded the digital revolution. This period was primarily driven by advancements in information and communication technologies, leading to the swift development of automated machinery and robots that revolutionized industry and information flow. In this era, the exchange of information and the penetration of technology began to profoundly impact daily life, social interactions, and the way business is conducted. Advancements during this time paralleled those of Industry 4.0, with a focus on the digitalization of communication and the enhanced integration of Internet technologies into the social fabric. These processes underscore the SST perspective that social progression shapes and is shaped by technological innovations.

The journey towards Society 5.0, the Super Smart Society, anticipates a future where technology is seamlessly integrated into all aspects of life, creating a balanced society that prioritizes both economic advancement and the resolution of social problems through a human-centred approach. This societal stage is expected to leverage advancements like AI and the IoT, not merely for economic growth but to enhance the quality of life for all. Therefore, the evolution from Societies 1.0 to 5.0 is not merely a chronicle of technological growth but a narrative of social transformation, mirroring and advancing alongside the wave of digital transformation. This evolution embodies the dyadic progression of society and technology, a foundational theme within the broad spectrum of theories seeking to explain the complex phenomena of digital transformation.

2.3.2 Technology-centric perspective

The current era of digital transformation is the culmination of significant advancements in digital technology, including big data, cloud computing, the IoT, blockchain, AI, and innovative algorithms. These technologies offer unparalleled potential and have substantially transformed traditional business and social frameworks. As noted in the *Global Education Monitoring Report* (UNESCO, 2023b), the intersection of information and communications technology (ICT) and education has a long history, dating back to the use of radio in the 1920s. However, it is the emergence and implementation of digital technologies over the past four decades that hold the most substantial potential for transformative impact within education.

A technology-driven perspective posits the evolution of technology as the primary catalyst for societal and institutional changes. This theoretical approach is especially pertinent when examining the wave of digital transformation, suggesting that technology serves not merely as a societal tool but as a force that shapes and defines society. This sentiment is echoed by Susskind and Susskind (2015) in their influential book, *The Future of the Professions: How Technology Will Transform the Work of Human Experts*. They argue that technological trends, particularly those in AI and online platforms, are reshaping economic and societal structures towards a digital era.

In the realm of education, this perspective underscores the radical transitions instigated by disruptive digital technologies, which fundamentally rearrange how education is delivered. Platforms such as Moodle and Canvas exemplify this shift, revolutionizing the administration of education through online course management,

delivery, and assessment. These platforms enable asynchronous learning, allowing students to engage with content at their convenience, thereby challenging traditional in-class education.

Moreover, the emergence of Massive Open Online Course (MOOC) platforms like Coursera and edX has significantly altered the higher education sector. These platforms have democratized education by offering courses from top-tier universities to a global online audience, undermining the monopolistic control of traditional higher education institutions (HEIs) and transcending the physical limitations of campus-based learning.

Venturing further into the realm of AI, adaptive learning systems utilizing AI are beginning to introduce personalized education solutions. These systems recognize individual learning patterns and knowledge deficits, offering a tailored learning experience that traditional methodologies cannot provide. Additionally, immersive augmented reality (AR) and virtual reality (VR) technologies are beginning to replace conventional learning techniques in certain domains. For instance, VR enables students to conduct chemical experiments within a safe, virtual environment.

This technology-focused viewpoint presents a compelling framework for examining digital transformation, emphasizing the role that disruptive technologies play in rewriting institutional norms and instigating societal shifts. However, it is crucial to acknowledge that the realization of digital transformation depends not only on technological breakthroughs but also on human agency. This leads to the subsequent discussion on the actor-centric perspective.

2.3.3 Actor-centric perspective

Digital transformation's complexity extends beyond the mere acquisition and deployment of new technologies. This multifaceted process is significantly influenced by human agency, where leaders, practitioners, and all organizational stakeholders play crucial roles in initiating, managing, and adapting to these changes.

Informed by Anthony Giddens' (1984) Structuration Theory, human agency and social structures are dynamically interwoven, continually influencing and reshaping each other. This framework is invaluable for understanding organizational changes during digital transformation, particularly how individual actions with technological tools drive structural evolution.

The role of human agency in digital transformation should not be underestimated. It encompasses the abilities of individuals within an organization to act autonomously and make strategic decisions that impact the transformation's trajectory. In this context, Organizational Learning Theory becomes particularly relevant, highlighting an entity's capacity to evolve and innovate—a capability fundamentally driven by its people's agency, which influences their interactions with technology and the creation of new knowledge and performance enhancements (Robey et al., 2000).

Empirical studies often underscore the importance of human actors in navigating digital transformation's complexities. They emphasize factors such as organizational culture, leadership, and staff engagement and competencies as critical success determinants (Porfírio et al., 2021; Wrede et al., 2020). Enterprises that exemplify digital transformation success often foster a culture that values continuous learning and innovation (Vey et al., 2017). Moreover, organizations that prioritize professional development through upskilling and reskilling initiatives are better positioned for resilience in rapidly evolving technological landscapes (Bailey et al., 2019).

Digital transformation is envisioned as a participatory social process within these studies. Organization members are not passive technology recipients but active agents who use, interface with, and ultimately shape the digital framework to serve their goals and responsibilities. In performing these roles, they act as critical connectors, bridging the latent capabilities of digital technologies and the realization of measurable benefits. Examining digital transformation in education through this actor-centric lens highlights the influential roles of educators, students, administrators, and technical support teams in advancing and overseeing these changes.

For instance, educators are instrumental in developing and integrating digital methods into curricula. Their digital fluency expertise directly impacts the quality of digital learning environments. Students—the direct beneficiaries of educational digitalization—are pivotal actors whose engagement and responsiveness to digital learning modalities are key to the transformation's effectiveness. Their interactions and feedback with e-learning systems are fundamental to these platforms' ongoing refinement. Administrators and school leaders form another vital group driving the digital transformation agenda. They are responsible for strategic decisions, such as teacher training initiatives, infrastructure investment, and partnerships with EdTech firms, which profoundly influence the pace and success of digital adoption. Technical support staff

also play a critical role in ensuring technological reliability and swiftly addressing issues, essential for maintaining the efficiency of digital educational frameworks.

In summary, an actor-centric perspective in digital transformation provides a comprehensive understanding that underscores the crucial role of individual and collective human agency. Regardless of the sector, be it education or otherwise, the coordinated efforts of each actor shape, drive, and maintain the transformation journey.

2.3.4 Ecosystem perspective

An ecosystem perspective on digital transformation offers a wider understanding of the complex network in which organizations operate. This understanding primarily stems from Network Theory, which highlights how organizations are embedded in a dense network of interconnections, with each entity functioning as a node within a broader, interdependent matrix (Borgatti & Halgin, 2011). The strength, diversity, and configuration of these network ties critically influence the flow of information, resources, and innovation—factors vital for successful digital transformation. This viewpoint is enriched by similar theoretical contributions that emphasize the complexity of interactions, the adaptation to emerging technologies, and the diffusion of innovations. These elements converge to form a robust, nuanced understanding of the organizational dynamics at play within a digital ecosystem. By integrating these theoretical insights, the digital ecosystem perspective captures the complex reality of how organizations digitally evolve and thrive, not in isolation, but through the collective co-evolution of their networks.

Much like what Moore (1996) referred to as a ‘business ecosystem’ in his seminal work, the ‘digital ecosystem’ extends beyond an organization’s internal setup to the larger surrounding network. This network involves a range of stakeholders—suppliers, customers, competitors, and others—interconnected through digital platforms. In this extensive interaction, transformation becomes a phenomenon that all ecosystem members continuously co-create and co-shape. Additionally, the digital ecosystem perspective recognizes that collective actions optimizing and harmonizing system interactions drive digital transformation (Pappas et al., 2018).

The application of the ecosystem perspective on digital transformation is distinctly visible in the rapidly evolving education sector. Today’s education extends beyond the traditional confines of physical classrooms and embraces digital platforms. These

platforms have the ability to develop tailored learning paths, ensure access, and reach remote students while fostering pedagogical innovations. This transformation of the education sector is linked to broader societal shifts, primarily visible in the transformation of the global labour market (Goulart et al., 2021). For instance, as workforce norms shift towards digitization, remote work, and digital collaboration, education systems must adapt by equipping students with the necessary digital skills sought by future employers. This symbiotic relationship underscores the inter-connectedness within the ecosystem, where changes in one component (the labour market) directly influence the other (education).

Furthermore, as HEIs increasingly adopt online learning for EdTech solutions, they form partnerships with technology providers and other stakeholders, creating an extensive digital ecosystem. This ecosystem is filled with interactions among students, educators, technology providers, and regulatory bodies, each shaping and modulating the digital experience. The ecosystem perspective emphasizes the need for education systems to optimize these interactions. A well-coordinated digital ecosystem in education could further stimulate innovation, inclusivity, and sustainability for future generations.

2.3.5 Connectivism perspective

Digital transformation in education has been profoundly influenced by connectivism, a theory that grapples with the fluid nature of knowledge in the digital age. Introduced by George Siemens (2008) and Stephen Downes (2005), connectivism posits that learning takes place within an extensive network of interconnected nodes, where information is dynamic rather than static. It recognizes the critical role of technology, positioning it not merely as a tool, but as a fundamental component of the learning ecosystem. In connectivism, the ability to continuously learn and connect with ever-expanding information sources is deemed more important than the accumulation of static knowledge.

The theory acknowledges that digital technologies have shifted the focus of learning from individual internalisation to networked intelligence, where external, distributed knowledge sources—from social media to online databases—become equally significant (Toumi, 2007). As such, connectivism challenges traditional pedagogy, advocating for an educational model that goes beyond classroom boundaries and embraces a more global, inclusive, and up-to-date approach to content dissemination.

Connectivism emphasizes that the ability to navigate and refine these information networks is crucial to keeping pace with the rapid changes typical of the digital era.

Moreover, connectivism introduces the idea that learning also occurs through machines—for instance, through AI and algorithms that customize educational content to meet the learner's needs. As technology and machine learning evolve, the connectivist approach co-evolves, further influencing how educational content is created, shared, and consumed. It not only incorporates digital transformation within its framework but actively fosters the evolution of educational practices in response to advancements in the digital domain. This reflects a synergy between educational theory and the progressive digitalization of the world, ensuring that education remains relevant and responsive in preparing learners for a fundamentally interconnected and technologically sophisticated society.

The theory of connectivism has, thus, evolved in response to and in parallel with digital transformation. It considers how technological advancements have altered the acquisition and distribution of knowledge and how this impacts the educational context.

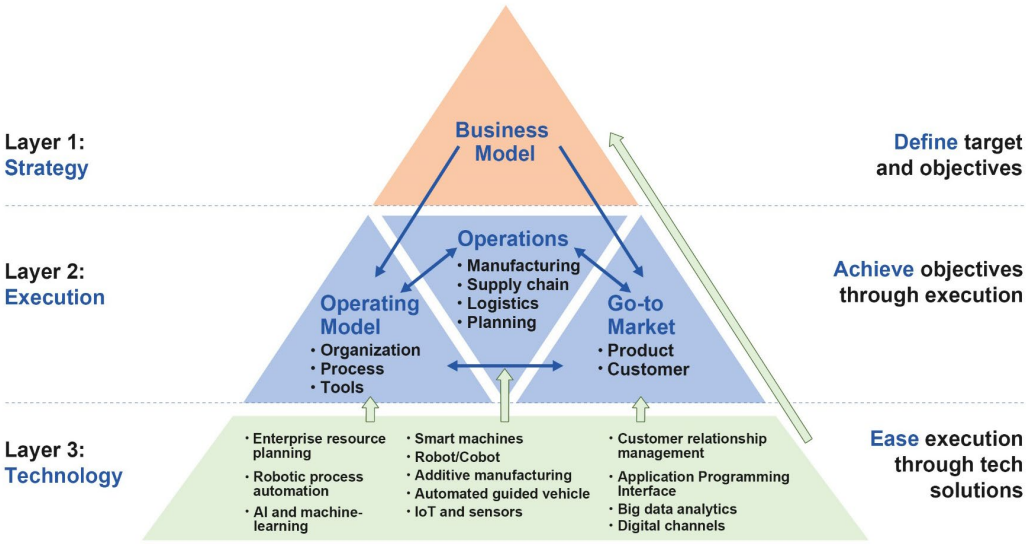
2.4 Frameworks for digital transformation in business and higher education contexts

This section presents two distinct frameworks of digital transformation, highlighting their implementation in both business and higher education contexts. Starting with the business context, which is arguably at the forefront of digital transformation due to its widespread application in the corporate world, the strategic model known as the 'Digital Transformation Pyramid' developed by Turchi (2018) is presented.

As depicted in Figure 2.2, the 'Digital Transformation Pyramid' is a structured approach designed to assist companies in navigating the complexities of integrating digital technology into their operations. The framework is built around three main levels: Strategy, Execution, and Technology. Strategy, at the top, emphasizes the need for a comprehensive business strategy that incorporates digital opportunities, threats, and innovations. Execution, in the middle, focuses on translating strategic plans into action and reflecting them through changes in the company's operations and go-to-market strategies. Finally, Technology, at the base of the pyramid, is seen as the essential tool that enables the execution of strategy and operational change. The framework insists on

an integrated review of these elements, asserting that successful digital transformation requires all these levels to work in harmony.

Figure 2.2 The Digital Transformation Pyramid



Source: Adapted from Turchi (2018, n.p.).

The framework is further elaborated by five key components: Business Model, Operating Model, Operations, Go-to Market, and a set of Enabling Technologies. These elements indicate that a transformation in business strategies and internal procedures, facilitated by technology, is crucial for authentic digital transformation. It is a comprehensive approach that evaluates and capitalizes on the synergy between strategy, implementation, and technology to propel corporate transformation.

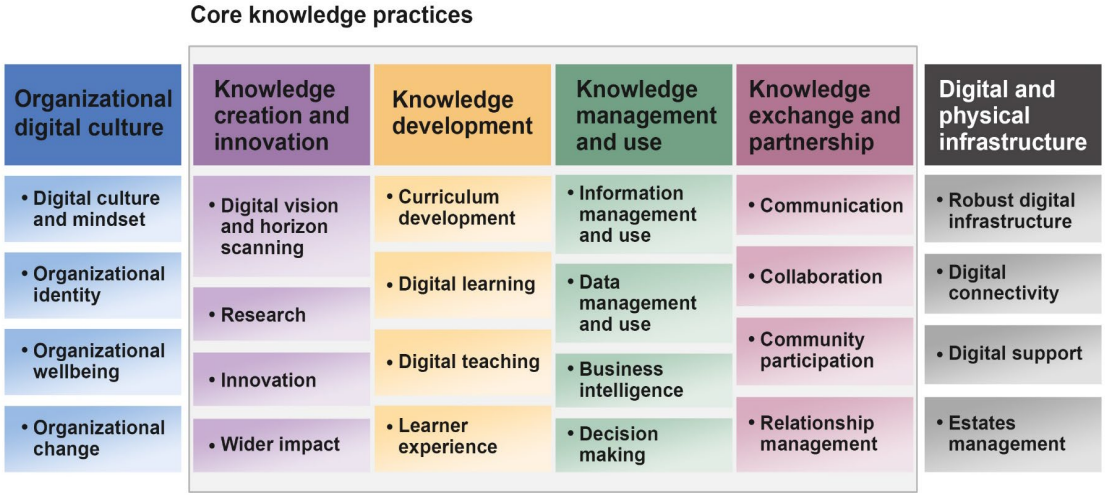
Similarly, formulating a clear strategy for digital transformation is equally critical for educational institutions. Figure 2.3 showcases a specialized 'Framework for Digital Transformation in Higher Education' devised by Jics, a UK-based consultancy specializing in data and technology in higher education. The framework offers a comprehensive perspective on integrating digital paradigms into the organizational culture, fundamental knowledge practices, and infrastructure of an educational institution.

The 'Framework for Digital Transformation in Higher Education' comprises six fundamental elements. Element 1, 'Organizational Digital Culture', advocates for the incorporation of digital technology into institutional values, beliefs, and practices. It recognizes that leadership in digital culture is not a passive position but an active involvement that requires strategy, investment, and a commitment to principles such as

digital safety, well-being, and equity. This cultural shift is vital for the successful integration of digital tools and for nurturing a community open to innovation and collaboration.

Elements 2 through 5 address the various aspects of knowledge—its creation, development, management, and exchange. Element 2, 'Knowledge Creation and Innovation', encourages institutions to keep pace with global trends and advancements to maintain competitiveness and relevance. Element 3, 'Knowledge Development', necessitates a rethinking of learning methodologies to empower stakeholders in a digital environment. Element 4, 'Knowledge Management and Use', emphasizes the strategic use of data to augment research, teaching, and decision-making processes within the institution. Element 5, 'Knowledge Exchange and Partnerships', fosters a collaborative culture that goes beyond organizational boundaries.

Figure 2.3 Framework for Digital Transformation in Higher Education



Source: Adapted from McGill (2023, p. 11).

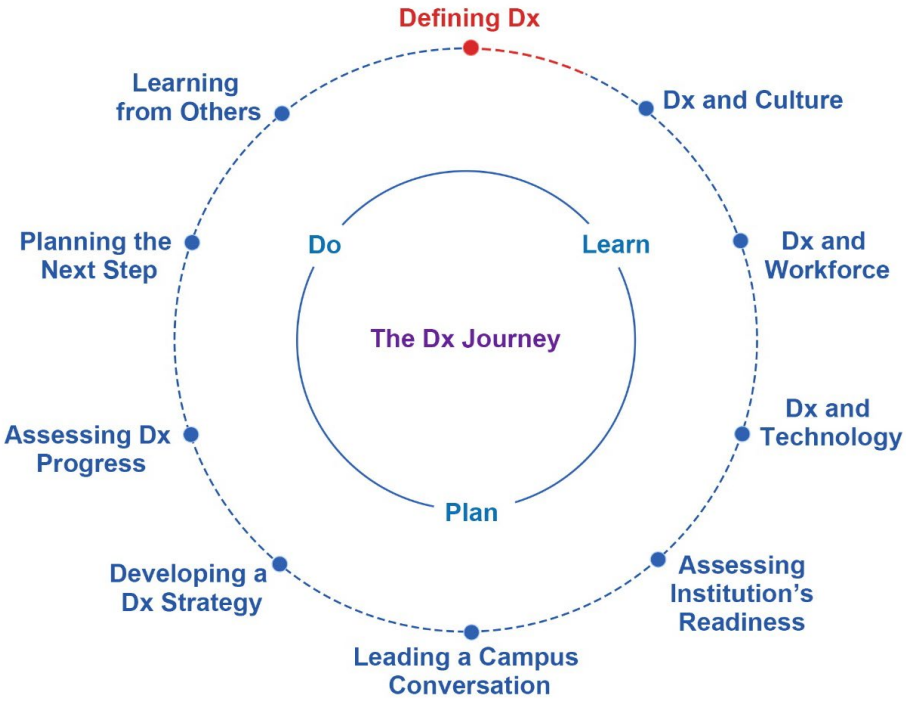
Lastly, Element 6, 'Digital and Physical Infrastructure', ensures that all digital initiatives are supported by robust, secure, and compliant infrastructure, providing a solid foundation for all technological pursuits.

Overall, this six-element framework provides HEIs with a comprehensive guide to modernize their operations, enhance their educational services, and foster an environment conducive to digital transformation.

2.5 Roadmap of digital transformation

Digital transformation is not a one-off project with a definite endpoint, but rather an ongoing cycle of learning, planning, and action, interspersed with regular periods of assessment and evolution. In this context, the 'Roadmap of Digital Transformation' (Figure 2.4) developed by EDUCAUSE offers a process-centric framework that is suitable for HEIs and other organizations. Notably, its tripartite approach—Learn, Plan, and Do—provides a cyclical and iterative journey of continuous improvement and adaptation.

Figure 2.4 Roadmap of Digital Transformation



Source: EDUCASE (https://dx.educause.edu/).

In the initial 'Learn' phase, the roadmap encourages institutions to grasp the fundamental elements of digital transformation within the academic environment, starting with clear definitions and identification of existing signs of transformation at the institution. The 'Plan' phase involves a comprehensive evaluation of the institution's current capabilities and the development of a strategic plan with clearly defined goals. It also emphasizes the creation of a collaborative environment by involving colleagues

across the entire campus in the transformative vision. The final 'Do' phase transitions the institution from planning to implementation—activating strategic actions designed to enhance institutional agility, responsiveness, and resilience. This includes a reflective process for monitoring impacts and adjusting plans as necessary.

The three-phase process involves multiple steps, such as defining the concept of digital transformation (Dx), aligning it with institutional culture, examining the intersection with workforce planning, and leveraging technology as a transformative tool. The process also addresses readiness, leading discussions to involve all stakeholders, strategy development, progress assessment, and planning next steps. Learning from others is also an integral part of the framework, facilitating the sharing of best practices and experiences to enrich and inform each institution's journey. After completing these steps, the process recommences by redefining Dx, symbolizing the iterative nature of continuous transformation within an institution.

2.6 Definition of digital transformation in TVET

TVET, as a learning segment that directly impacts the vocational and professional skill sets of learners, is at the forefront of this digital revolution. The new UNESCO TVET Strategy (UNESCO, 2022) and the UNEVOC focal projects underline the importance of digital transformation and its role in the creation of resilient societies. UNESCO (2023a, p. 19) defines digital transformation in TVET as '*the planned and structured introduction of technology into institutions and national TVET systems, with the goal of enhancing scope, scale, efficiency and effectiveness, ultimately driving more sustainable development*'. Specifically, digital transformation in TVET occurs across four levels of increased complexity and sophistication:

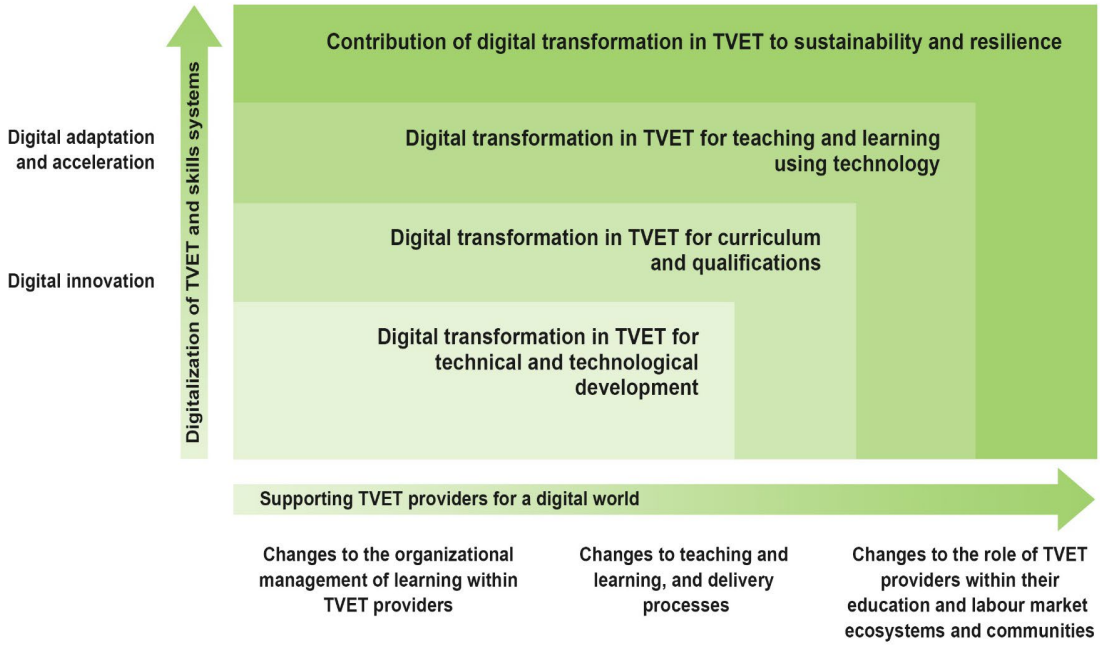
- Technical and technological development
- Curriculum and qualifications
- Teaching and learning using technology
- Sustainability and resilience

Based on the definition provided by UNESCO, digital transformation in the TVET sector involves not just the simple introduction of technology into the system, but a planned and structured process. This integration of technology aims to improve the overall scope of TVET, scale its reach, enhance efficiency and operational effectiveness, and pave the way towards more sustainable development in the sector. Analyzing these

key components reveals a strategic layout for the optimal implementation of technology in TVET. Reflecting the aforementioned definition of digital transformation in TVET, UNESCO (2023a) has introduced a framework that illustrates the four stages of this transformation.

As depicted in Figure 2.5, the digital transformation framework for TVET consists of four primary levels. The initial level entails the incorporation of technology into TVET systems. This process involves establishing the necessary infrastructure, such as hardware and software, and digitizing administrative procedures, including student enrolment, course records, and financial records. The pivotal step here is the transition from paper to digital records, which facilitates the exchange and organization of information across divisions, thereby supporting automated processes and strategic decision-making in TVET.

Figure 2.5 Four-level conceptual framework for digital transformation in TVET



Source: UNESCO (2023a, p. 11).

The second level concentrates on the transformation of the curriculum and qualifications. This stage involves introducing new knowledge and skills, such as cybersecurity and cloud computing, or integrating digital skills into existing courses. Successful digital transformation at this level requires synthesizing data from various

sources, including enrolment and student survey data, industry data, and partner data, to identify new skill needs and necessary curriculum revisions.

The third level relates to the digital transformation of teaching and learning. This level involves digitizing learning records, incorporating new teaching modes such as blended or remote learning, and utilizing new tools for learning and assessments. Success at this level is characterized by teachers and students effectively engaging through digital platforms, improving access, and achieving learning outcomes comparable to, if not better than, traditional methods.

The fourth and most advanced level concerns the contribution of digital transformation in TVET to sustainability and resilience. This level involves applying digitally enabled practices that contribute to sustainable development and resilient societies. It encompasses several actions outlined by the *UNESCO Strategy for TVET (2022–2029)*, focusing on skills necessary for digital and green economies, addressing youth unemployment, enhancing Science, Technology, Engineering, and Mathematics (STEM) skills, fostering innovation in teaching, and promoting TVET institutions as centres for social integration and green citizenship.

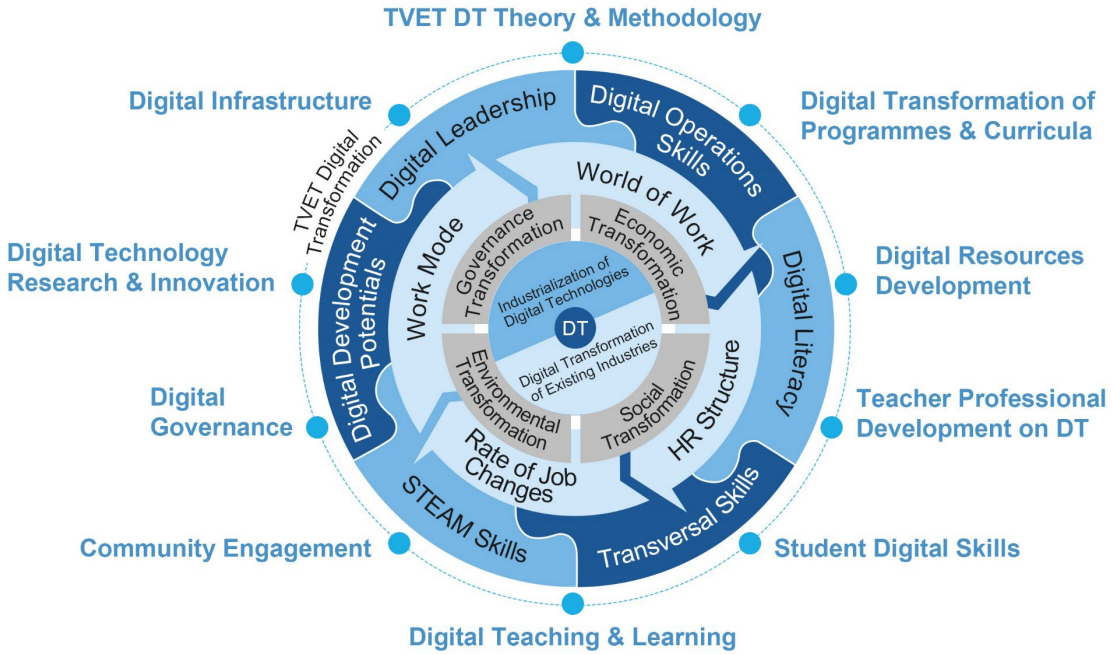
Two cross-cutting components facilitate this journey. The first is the provision of adequate human and financial resources, which are foundational to all levels of the framework, from infrastructure setup to supporting sustainability. The second cross-cutting component is the continuous and deepening digital innovation, which spans three categories: (1) digital innovation, supporting new pedagogies of teaching and learning; (2) digital adaptation, facilitating the teaching of new skills to adapt to societal and labour market changes; and (3) digital acceleration, escalating existing policies.

2.7 Proposed framework for digital transformation in TVET

Digital transformation in TVET is a multifaceted process that unfolds across diverse yet interconnected aspects. It necessitates the consideration of evolutionary matrices in various areas. Drawing on the insights of UNESCO (2023a) and previous frameworks, and building on the practices of Shenzhen Polytechnic University, this report proposes a framework that integrates the logic of digital transformation for TVET. This framework delineates a systematic roadmap for TVET institutions to undertake digital transformation.

As depicted in Figure 2.6, digital transformation in TVET is deeply rooted in a sequence of transformative waves driven by innovation and societal shifts. This transformation is not an isolated event, but a logical response to a series of interconnected precursors and demands arising from advancements and changes in technology, industry, the broader economy, society, and the workplace. As job roles evolve, the demand for digital skills grows exponentially, leading to significant mismatches and shortages of digital skills in the labour market. Given these complex dynamics, there is a pressing need to digitally transform TVET to incorporate comprehensive digital skills training, ensuring that graduates are proficient in utilizing digital tools and technologies. By aligning TVET with the demands of the digital economy and the transformed world of work, individuals can be better equipped to meet the evolving needs of industries and contribute significantly to the digital-driven economy.

Figure 2.6 Framework of logic and actions for digital transformation in TVET



Source: Authors.

At the fundamental level, digital transformation in TVET revolves around two pivotal processes that synergize the evolution of industry in the landscape of digital technology. The first process, 'the industrialization of digital technologies', signifies the advancement and extensive integration of digital technologies across various industrial

sectors. This process involves not only the proliferation of digital tools and systems but also the establishment of digital infrastructure as a standard operational element within different sectors of the economy. The ubiquity of such technologies as IoT devices, big data analytics, cloud computing, and AI exemplifies this trend. As digital technologies become deeply embedded in industrial operations, they catalyze efficiencies, foster innovation, and drive the creation of new value chains and business models.

The second process, 'the digital transformation of existing industries', involves the metamorphosis of long-established industries through the adoption of digital technologies. Traditional industries, ranging from manufacturing to agriculture, are redefining their processes, products, and services by leveraging digital tools, thereby enhancing productivity, sustainability, and customization. This transformation extends beyond technological upgrades and requires a holistic change in corporate culture, workforce skills, and business operations to fully harness the benefits of digital adoption. It encompasses the modernization of manufacturing with smart factories, digital networks that optimize supply chains, and service sector innovations through digital platforms.

Understanding and facilitating these two processes is crucial for TVET. The industrialization of digital technologies necessitates a workforce proficient in technological literacy, adaptable to rapid changes in the tech landscape, and capable of innovating within digital ecosystems. Meanwhile, the digital transformation of traditional industries requires TVET institutions to stay ahead of the curve by continuously updating curricula, fostering digital skills, and aligning with industry needs. Emerging from this fundamental level, the ripple effect of digital transformation is distinctly seen across society, economy, governance, and the environment. While these domains are individual influencers, they concurrently impact each other.

- **Economic transformation**: The rising wave of the digital economy serves as a focal point for understanding the rationale behind digital transformation in TVET. As traditional disciplines and vocational skills become increasingly basic, the digital economy necessitates a shift towards innovative, multifaceted competencies. This adaptation to market needs underscores the need for TVET systems to undergo a comprehensive digital overhaul.
- **Social transformation**: Societal changes, exemplified by shifts towards sustainable living, the rise of digitization, the phenomenon of reverse globalization, and the COVID-19 pandemic, necessitate an adaptive educational

framework like never before. Each societal wave carries implications for the world of work, thus invoking educational transformations within TVET.

- **Governance transformation**: Governments play a central role in guiding this transformation, with policies and regulatory measures forming part of the larger digital tectonic plates shifting beneath the TVET system. These changes are also driven by economic shifts towards industrial digitization and digital industrialization, a drive that is redefining skill requirements and thereby reconfiguring TVET's deliverables.
- **Environmental transformation**: The digital sector's energy consumption induces significant greenhouse gas emissions that exacerbate climate change and various environmental issues. There is an urgent need for institutions to minimize digital carbon footprints in their daily operations while leveraging green technologies for eco-friendly innovations. This context urges the inclusion of green skills and the development of an ecological mindset into TVET programmes to foster sustainable practices.

These broader changes in economic, social, governance, and environmental areas significantly impact the configuration and operation of various domains regarding modern work, affecting the mode of work, rate of job changes, human resource structures, and the complex network of employment relations in the world of work.

- **Mode of work**: The universally practised mode of work is currently undergoing an unprecedented transformation due to digital advances. The shift from conventional, physical working environments to remote or hybrid ones, powered by digital platforms and collaborative tools, is a direct result of societal shifts towards digital literacy, economic progress through digitization, and governance policies promoting digital transitions. Environmental concerns, such as reducing carbon footprints, also support virtual modes of work.
- **Job changes**: Accelerated job changes have become a reality in the digital era. As economies move toward the digital frontier, traditional roles are rapidly metamorphosing or becoming obsolete, while novel, digital-centric roles are emerging. Notably, societal emphasis on digital competency, supportive policy measures, and environmental sustainability factors like green jobs are accelerating these changes.

- **Human resources (HR) structure**: Social acceptance of digital processes, economic feasibility, digital regulations, and environmental compliance all contribute to a more digital-centric HR structure. This necessitates a shift from process-driven, bureaucratic routines to agile, learner-centred, and technology-optimized operations.
- **The world of work**: The broader work environment, characterized by intricate relationships among employers, employees, and job markets, is undergoing a reinvention in the digital era. Digital transformation influences work arrangements (for instance, the rise of gig work facilitated by digital platforms), labour markets (global talent pools), skill requirements (with traditional skills being supplemented or replaced by new digital skills), and employer-employee relationships (through new employment methods). Societal trends, economic factors, governance (including labour laws), and considerations for environmental sustainability are crucial in driving these changes.

In response to these shifts, TVET institutions must proactively transform. This transformation necessitates the adoption of digital leadership, enhancement of digital literacy among educators and learners, prioritization of Science, Technology, Engineering, Arts, and Mathematics (STEAM) skills, transversal skills, and digital operations skills, and the unlocking of potential development opportunities with various digital tools. These areas of transformation can be distilled into practical approaches that TVET institutions can utilize when designing digital transformation strategies:

- **Cultivating students' digital literacy and skills**: TVET institutions should prioritize building a robust foundation of digital literacy among students, equipping them with the necessary skills to navigate and contribute effectively to the digital economy.
- **Deepening integration of education with industry**: Collaboration between TVET institutions and industries must be strengthened to ensure that education aligns with current and emerging industry needs, preparing students for real-world challenges.
- **Enhancing teachers' professional development on digital transformation**: Upskilling teachers in digital methods and technologies is critical to facilitating transformative digital learning experiences for students.

- **Digital transformation of programmes and curricula**: Existing curricula and programme structures should be updated and digitalized to reflect advances in digital technology and its applications across industries.
- **Digital resource development**: TVET institutions should foster the development and utilization of digital resources for learning, such as e-books, digital labs, and online learning platforms, to enhance the learning process.
- **Increasing community engagement**: Incorporating digital technologies in community engagement activities—at domestic, regional, and global levels—can extend learning beyond the classroom and foster lifelong learning habits.
- **Digital technology research and innovation**: TVET institutions should encourage research and innovation in digital technology, fostering a culture of curiosity and continual learning.
- **Research on TVET digital transformation theories and practices**: Commitment to research on the theories and practical aspects of digital transformation within TVET is vital to understanding its impact and how it can be improved.
- **Enhancing digital governance**: Streamlining governance processes using digital platforms can increase the efficiency and transparency of TVET institutions.
- **Consolidating digital infrastructures**: TVET institutions must prioritize investing in up-to-date digital infrastructures to support the successful implementation of digital transformation strategies on a wide scale.

Overall, these aspects collectively form a comprehensive structure that encapsulates the rationale, effects, and methods for digital transformation in TVET. This framework serves as a roadmap, clarifying the complex journey of TVET's digital transformation by providing guidance on the necessity of transformation, the process of change, and potential directions for TVET institutions. The subsequent chapters of this report will delve into various aspects of the transformation, offering practical insights, case studies, potential challenges, and solutions to facilitate successful implementation.

2.8 Summary

This chapter underscores that digital transformation is a systematic and iterative process. It is not a one-off event, but a continuous, dynamic process that necessitates systematic planning, implementation, and evaluation. It comprises a series of interconnected steps

and adaptations that must be revisited and refined over time. The iterative nature of digital transformation mirrors its adaptability to changing technological landscapes, market demands, and organizational needs. Each phase of the process, be it digitization, digitalization, or holistic transformation, requires careful consideration of current capabilities, stakeholder needs, and strategic goals. Furthermore, digital transformation is not a linear progression, but an ongoing journey that requires organizational learning, adaptation, and resilience to effectively navigate the complexities of the digital age.

Second, a digital mindset is the cornerstone of successful digital transformation. The effective execution of digital transformation depends on fostering a digital mindset within an organization. This mindset embodies a culture that prioritizes digital literacy, leadership, and adaptability. It necessitates individuals at all organizational levels to view digital technologies as catalysts for progress and to proactively seek opportunities for digital integration and transformation. Successful digital transformation requires a workforce proficient in using digital tools and capable of conceptualizing and implementing innovative solutions that leverage these technologies to enhance institutional value and competitive advantage. To cultivate digital-mindedness, TVET institutions must invest in continuous learning and development programmes that encourage experimentation, foster digital innovation, and promote a culture of collaboration and openness to change.

Third, digital transformation must be implemented extensively and deeply across the entire TVET system. The implementation of digital transformation within TVET institutions is a complex, multidimensional process that extends beyond merely incorporating new technologies into educational practices. It involves thoroughly reshaping institutional strategies, redesigning pedagogical approaches, revamping administrative processes, and leveraging digital tools to enhance teaching, learning, and operational efficiency.

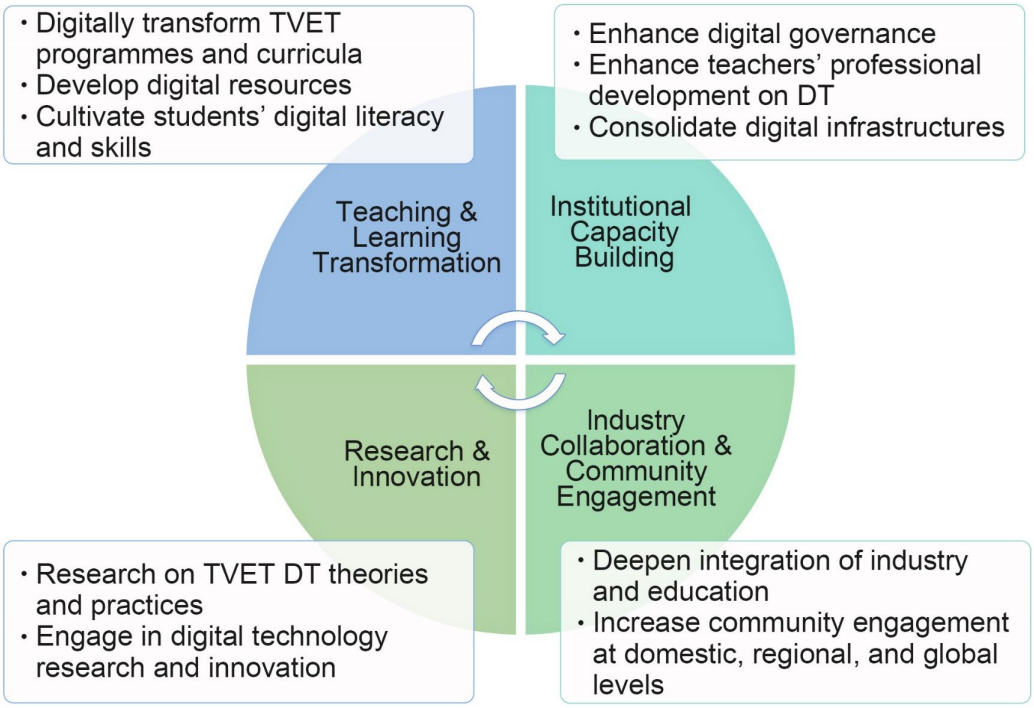
To further summarize our proposed digital transformation methodology, there are four domains that TVET institutions should focus on when planning their digital transformation journey, as outlined in Figure 2.7.

Domain 1: Teaching and Learning Transformation

- Transform TVET programmes and curricula digitally by revamping the educational syllabi to integrate digital tools and skills pertinent to current and future job markets.

- Develop digital resources by creating digital learning materials that students and faculty can utilize to enhance the practical learning experience.
- Cultivate students' digital literacy and skills to ensure they acquire the essential digital skills needed for modern workplaces.

Figure 2.7 Four domains of digital transformation in TVET



Source: Authors.

Domain 2: Institutional Capacity Building

- Enhance digital governance by streamlining institutional processes to effectively support digital initiatives.
- Improve teachers' professional development in digital transformation by providing continuous training for educators to develop their understanding and digital teaching methods.
- Consolidate digital infrastructures to ensure the technical and physical infrastructure supports a digitally transformed educational environment.

Domain 3: Research and Innovation

- Engage in research on TVET digital transformation theories and practices by conducting an in-depth analysis of current educational and technological trends, tools, and methodologies and their implications for TVET.

- Engage in digital technology research and innovation by collaborating with industry for the development of new technologies and approaches that have immediate applications in TVET sectors.

Domain 4: Industry Collaboration and Community Engagement

- Deepen the integration of industry and education by building partnerships that ensure alignment with industry needs and facilitate a smooth transition of students into employment.
- Increase community engagement at domestic, regional, and global levels by using digital tools to strengthen ties with other institutions, businesses, and the broader community.

The digital transformation of TVET is unquestionably intricate and cannot be accomplished instantaneously. It necessitates a gradual adaptation, as opposed to a sudden shift. TVET institutions ought to perceive the digital transformation as a step-by-step, yet all-encompassing strategy, commencing with their existing strengths and priorities to optimize their distinct capabilities. By concentrating on the areas most pertinent to their context and progressively extending into other sectors, they can devise a customized roadmap that corresponds with their specific objectives and resources.

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Chapter 3

Digital Transformation of TVET Governance

Xiuzhen Zeng

This chapter delves into the digital transformation within the governance of Technical and Vocational Education and Training (TVET). It begins by outlining the landscape of international, regional, and national strategies driving this digital shift. The chapter then examines governance frameworks, mechanisms, and sequential steps essential for navigating the intricate process of TVET digital transformation. With an emphasis on the diverse TVET ecosystem, it scrutinizes various models, stakeholders, and a bespoke governance framework aimed at policy reform in the digital age. This sets the groundwork for a more in-depth exploration of the theories, frameworks, and strategic approaches shaping TVET's future.

3.1 International, regional, and national strategies for digital transformation of TVET

3.1.1 Strategies of international organizations

International organizations play a crucial role in influencing and guiding the digital transformation of education, encompassing both governmental and non-governmental

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aspects. Among these, governmental influence and leadership are particularly notable. Key global international organizations in the field of education include the United Nations Education, Scientific and Cultural Organization (UNESCO), International Telecommunication Union (ITU), the International Labour Organization (ILO), the World Bank, and the Organisation for Economic Co-operation and Development (OECD). In recent years, these organizations have consistently concentrated their efforts on digital transformation, issuing corresponding strategic agendas, initiative plans, or guiding documents to direct and accelerate the digital transformation processes within the field of education.

(1) United Nations Education, Scientific and Cultural Organization

UNESCO has published a series of critical documents and standards that have been instrumental in guiding global education toward the adoption of digital technologies. These documents and standards illustrate UNESCO's multifaceted roles as a think tank, standard-setter, capacity builder, information disseminator, and advocate for international cooperation (The Secretariat of the Global MOOC and Online Education Alliance, 2023). This comprehensive effort by UNESCO has significantly influenced the digital transformation of higher education worldwide, including the TVET sector. Notably, the 'Education 2030 Framework for Action' serves as a comprehensive guide for implementing Sustainable Development Goal (SDG) 4, dedicated to ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all (UNESCO, 2015). Although established before the intensified focus on digital transformation in education, its principles and objectives remain deeply relevant in the context of digitalization. Moreover, the *Medium-Term Strategy 2022-2025* of the UNESCO Institute for Information Technologies in Education (IITE) focuses on addressing inclusive and equitable education in the digital era to achieve SDGs (UNESCO IITE, 2022). The *UNESCO Strategy for TVET 2022-2029* integrates digital transformation by developing flexible digital learning pathways, micro-credential frameworks, and skills for digital and green economies (UNESCO, 2022). It utilizes digital tools to enhance global citizenship and sustainable development education in TVET, focusing on inclusivity, accessibility, and adaptability, thereby meeting the demands of a digitized global landscape.

(2) International Telecommunication Union

The ITU has proactively accelerated the digital transformation of the global education sector. Established by the ITU in 1969, World Telecommunication Day underscores the importance of the telecommunications industry and fosters a vision of shared information and development. In 2021, the ITU-themed World Telecommunication Day as 'Accelerating Digital Transformation in Challenging Times', emphasizing the urgency of global digital transformation (ITU, 2021a). In June 2020, the ITU launched the Digital Skills Assessment Guidebook, a comprehensive tool for national digital skills assessments. It aids policymakers and stakeholders in identifying the supply of digital skills, assessing industry demand, pinpointing skill gaps, and formulating policies for future needs (ITU, 2021b). The report, *The Digital Transformation of Education: Connecting Schools, Empowering Learners*, was jointly released by the BCSD, ITU, UNESCO, and UNICEF (BCSD et al., 2020). It emphasizes the significance of connecting schools to enhance educational systems and achieve SDGs, offer tools and frameworks for governments to establish school connectivity strategies, provide insights for future financing models to meet broadband targets, and encourage engagement from various sectors to support school connectivity initiatives.

(3) International Labour Organization

The ILO has implemented strategies for digital transformation, focusing on enhancing digital skills and technology integration in labour markets. The 'ILO-ITU Digital Skills Campaign', in collaboration with the ITU, aims to develop digital skills among youth, crucial for the digital economy (ITU Academy, n.d.). The ILO has developed an extensive framework in *Digitalization of National TVET and Skills Systems: Harnessing Technology to Support Lifelong Learning (LLL)*, outlining strategies for embedding digital technologies in TVET systems to promote lifelong learning and align with labour market needs (ILO, 2021). Additionally, the ILO's *World Employment and Social Outlook: Trends 2023* provides an in-depth analysis of digital transformation's impact on global employment, offering insights into the challenges and opportunities of the digital era (ILO, 2023).

(4) World Bank

While primarily an international financial institution, the World Bank is committed to reducing poverty, promoting sustainable development, and improving global living standards (World Bank, 2020). Recognizing education's pivotal role in long-term national development and poverty reduction, the World Bank has actively supported various education-related projects and initiatives. In June 2021, the World Bank provided $500 million in funding to Uganda, Cameroon, and Ghana to support infrastructure development, laying the foundation for digital strategic actions in the education sector (The Secretariat of Global MOOC and Online Education Alliance, 2023). In 2021, the World Bank released *Steering Tertiary Education: Toward Resilient Systems that Deliver for All*, highlighting the need for education systems to undergo digital transformation to meet the demands of modern society and learners (World Bank, 2021). The significance of digital transformation lies in its potential to enhance the accessibility, quality, and sustainability of education, contributing to the development of more resilient higher education systems, including the TVET system.

(5) Organisation for Economic Co-operation and Development

The OECD's role extends beyond economics, encompassing extensive policy research and coordination, including in the education sector. Actively engaged in education policy and research, the OECD supports countries in enhancing the quality and accessibility of their education systems through data, analysis, and policy recommendations (OECD, 2020). In 2019, the OECD published *OECD Skills Outlook 2019: Thriving in a Digital World*, which emphasizes the evolving demands for skills and education in the digital age and how digital transformation in education can meet these requirements (OECD, 2019). This report offers crucial insights for policymakers and educational institutions on fostering skills adaptable to the digital world. The *OECD 2030 Learning Framework*, introduced in 2015, aims to guide future education policies and practices (OECD, 2015). It highlights the importance of diversity, social inclusivity, digitalization, and lifelong learning in education. This framework is closely tied to the digital transformation of TVET, as digital technology is considered a key tool for achieving more flexible, comprehensive, and inclusive educational goals.

In summary, UNESCO, the ITU, the World Bank, and the OECD all underscore the importance of digital transformation in the global education arena. They concur that the application of digital technology enhances the quality, accessibility, and flexibility of

education. These international organizations focus on global educational issues, particularly addressing global challenges in education. These challenges encompass improving educational quality, reducing inequality, promoting inclusive education, and enhancing students' digital skills worldwide. Through the publication of research and policy recommendations, they support governments and educational institutions across countries, aiding them in better understanding and responding to the opportunities and challenges posed by digital transformation. Despite their distinct expertise, missions, and differences in focus, audiences, and roles, they typically collaborate and coordinate efforts to collectively advance the global digital transformation of education. This collaborative approach aims to cater to the diverse needs of education sectors in various countries, including TVET.

3.1.2 Strategies of regional organizations

Regional international organizations, established to foster cooperation, stability, development, and common interests among member countries and address shared challenges and issues, play a pivotal role in promoting peace, prosperity, and collaboration. To adapt to economic changes, enhance employment opportunities, bridge skill gaps, promote innovation and entrepreneurship, and achieve goals such as social inclusivity and sustainable development, these organizations have published several strategic documents to ensure that digital transformation is prioritized in education sector reforms.

(1) Association of Southeast Asian Nations

The *ASEAN Education Work Plan 2021-2025* of the Association of Southeast Asian Nations (ASEAN) highlights key areas such as enhancing education quality, fostering student mobility, and implementing digital transformation in education (ASEAN, 2021). It acknowledges digital transformation as an essential strategy to tackle contemporary educational challenges.

In August 2022, the Third China-ASEAN Education Ministers Roundtable Conference introduced the strategic document, *Building an Amicable Home Together: Vision and Action on ASEAN-China Education Cooperation and Development (2022-2030)*. This document delineates the formation of the China-ASEAN Digital Education

Alliance (ASEAN, 2022), emphasizing the need for an innovative, inclusive, and sustainable educational community. It also identifies primary areas of cooperation between China and ASEAN in digital education.

(2) Southeast Asian Ministers of Education Organization

The Southeast Asian Ministers of Education Organization (SEAMEO) advances TVET in Southeast Asia through its SEA-TVET programme. A significant initiative under this programme is the SEA-TVET Consortium, which aims to internationalize and harmonize TVET standards. It encourages student and staff exchanges, cross-country industrial attachments, and internships (SEAMEO, n.d.). The consortium seeks to establish partnerships between TVET institutions and industry sectors and to create a sustainable networking platform among TVET leaders, institutions, and industry. It is vital in modernizing TVET education, aligning it with the demands of the digital era, and preparing students for the future workforce.

(3) African Union

In 2022, the African Union (AU) introduced the *African Union Digital Education Strategy and Implementation Plan (2023-2028)*. This plan provides a comprehensive framework to boost the adoption of digital technologies in education across the continent. Aligned with the *Continental Education Strategy for Africa: 2016-2025*, the strategy focuses on integrating digital tools and methodologies into the education systems of member states. It addresses the digital divide, promotes digital literacy, and ensures the utilization of digital technologies to enhance educational outcomes and accessibility (AU, 2022). Moreover, the *Digital Transformation Strategy for Africa (2020-2030)* offers a broader approach, covering various sectors, including education. It aims to guide the continent-wide digital transformation process (AU, 2020). This strategy includes policy recommendations for enhancing digital education, advancing the use of digital technologies, and raising public awareness about digital competencies. It covers digital education at all levels, including TVET, highlighting the importance of digital skills within the workforce.

(4) European Union

The European Union (EU) has been an early adopter in recognizing the significance of digital transformation in education. As early as 2013, it introduced the *Digital Competences Framework* (DigComp), which provides specific guidance for assessing digital literacy in higher education (EU, 2022). Additionally, the EU has implemented strategic plans such as the *Digital Education Action Plan (2021-2027)*, focusing on actions related to digitalization (EU, 2020). These actions demonstrate the EU's commitment to using digital technology in education, aligning with the core principles and objectives of educational digitalization.

The strategies and actions of these regional international organizations underscore the importance of digital transformation, particularly in connection with TVET. The TVET sector must concentrate on cultivating digital skills to adapt to the changing work environment. However, due to geographical variations among these organizations, digital transformation faces unique challenges, potentially leading to differences in policies and initiatives based on regional needs. Nevertheless, all these organizations acknowledge the importance of international cooperation in ensuring the sustainable development and adaptability of the TVET sector, fostering the skills and competencies needed to tackle future professional challenges and promote socioeconomic sustainability.

3.1.3 Strategies of national governments

To keep the education system in sync with the constantly evolving digital landscape and equip students with the necessary future skills and knowledge, numerous countries have developed national-level digital transformation strategies in recent years. A study by Huawei (2022) reveals that, to date, 170 countries and regions worldwide have introduced digital transformation strategies. This section will introduce the respective digital transformation strategies of representative countries from Asia-Pacific, Europe, the Americas, and Africa.

(1) Africa

Kenya: In Africa, Kenya's *National Information Communication and Technology Policy Guidelines (2020)* represent a significant step towards enhancing its ICT sector, with a focus on socioeconomic development and digital transformation. This policy supports

Kenya's ambition to transition into a knowledge-based economy, using ICT as a key driver for national progress (Bowmans, 2020).

South Africa: Africa's *National Digital and Future Skills Strategy* establishes a progressive framework to prepare the nation for the digital economy and future work trends. This strategy covers digital skill development, education system reform, public-private partnerships, infrastructure development, and government digitization, among other key areas. It signifies South Africa's commitment to leveraging digital technologies for economic growth and social development and enhancing its global competitiveness (Department of Communications and Digital Technologies, 2020).

(2) Americas

Brazil: Introduced by the Brazilian government in 2018, the *Brazilian Digital Transformation Strategy* underscores the importance of digital talent as a pivotal component of the digital economy. The strategy advocates for the integration of network security education into curricula, promotes the creation of university programmes related to cybersecurity, and implements initiatives such as the 'Acceleration Digital Transformation Initiative' to augment ICT and Internet usage in education. These endeavours aim to offer remote learning opportunities and computer technology training, demonstrating Brazil's dedication to digital progression in education (Stock, 2023).

Canada: Launched in 2014, *Connecting Canadians – Digital Canada 150* embodies Canada's blueprint for its digital future, projecting the nation's accomplishments by its 150th anniversary in 2017 and beyond (Innovation, Science and Economic Development Canada, 2014). The strategy encompasses various facets of digital transformation, including infrastructure, skills development, and innovation. In the domain of AI, Canada has executed the *Pan-Canadian Artificial Intelligence Strategy*, concentrating on AI research and development, maintaining competitiveness in the AI field, and addressing the ethical and societal implications of AI.

United States: The US government, via its Department of Education and associated agencies, allocates funding and resources to bolster digital transformation in education. This includes the introduction of several versions of the *National Education Technology*

Plan, focusing on digital infrastructure, EdTech, and online learning resources. Furthermore, the US has published guidance documents such as *Reimagining the Role of Technology in Education: Preparing for the Future* (Office of Educational Technology, 2017), providing a comprehensive framework for advancing EdTech. A national strategy pertinent to digital transformation and emerging technologies seeks to strengthen the economy, generate jobs, enhance sustainability, address climate change, ensure national security, and improve healthcare (US Department of Commerce, 2022). It gives priority to the development of advanced manufacturing technologies, the expansion of the skilled workforce, and the reinforcement of the manufacturing supply chain.

(3) Asia-Pacific

Australia: The Australian government fervently advocates for digital education through a series of strategic initiatives and policies, including the *Digital Economy Strategy 2030* and the *Digital Literacy Skills Framework* (Government of Australia, 2021). These strategies aim to enhance Australians' digital skills. By emphasizing contemporary, evidence-based learning methods, the government invests in delivering personalized education through digital means. The *Digital Literacy Skills Framework* further expounds on the need for students to acquire comprehensive information literacy and digital skills. These encompass writing, integration, and innovation skills, which are vital for addressing future global challenges. Additionally, *The Future of Education Strategy* (ACT Government Education Directorate, 2017) exemplifies Australia's commitment to modernized learning, ensuring that students have access to digital learning environments.

China: China has implemented several strategies to expedite its digital transformation. The *Plan for the Overall Layout of Building a Digital China* envisions China as a global leader in digitalization by 2035, emphasizing the application of digital technology across various sectors (State Council, 2023). Strategies such as *Broadband China* and *Internet Plus* concentrate on infrastructure development and the integration of the Internet with traditional industries. The *Thirteenth Five-Year Plan for National Strategic Emerging Industries Development* underscores the advancement of 5G technology, highlighting China's ambition to lead in this field (State Council, 2016). Furthermore, the *New Generation Artificial Intelligence Development Plan* focuses on AI technology

development, industry cultivation, and innovation systems (State Council, 2017). These initiatives demonstrate China's holistic approach to digital transformation, encompassing infrastructure, telecommunications, and advanced technology sectors.

New Zealand: The *2019 New Zealand Cyber Security Strategy* emphasizes enhancing cybersecurity, boosting digital capabilities in small enterprises, and improving rural connectivity. This effort's key component supports cyber-aware citizens and a resilient digital realm (Department of the Prime Minister and Cabinet, 2019). The *Digital Boost Programme* further assists small businesses in developing digital skills. Additionally, initiatives like the *Remote Users Scheme (RUS)* aim to expand connectivity in rural areas, ensuring nationwide digital access (NZ Digital Government, 2022).

Singapore: Launched in 2014, Singapore's *Smart Nation* initiative aims to leverage Infocom technologies, networks, and big data to create tech-enabled solutions. Aspiring to be a world-class, technology-driven city-state, Singapore is transforming into a *Smart Nation*. This transformation involves integrating technology into the daily lives and business operations of its citizens. Amid the digital revolution, Singapore is focused on harnessing technology to enhance its digital society, economy, and government, laying the groundwork for a comprehensive digital ecosystem (Smart Nation Singapore, n.d.).

South Korea: South Korea's comprehensive AI strategy, known as the *National Strategy for Artificial Intelligence*, positions the country as a global AI leader. Launched as a policy paper, it outlines the nation's vision and steps toward fostering AI technology growth. This strategy embodies South Korea's ambition to be at the forefront of AI, addressing the industrial and societal implications of AI development and application (Ministry of Science and ICT, 2019). The approach is multifaceted, incorporating technological advancements, regulatory frameworks, educational initiatives, and ethical considerations, thus showcasing South Korea's integrated and proactive approach to AI as a central element of its future growth.

(4) Europe

France: Adopted by the Minister of National Education and Youth, France's *Digital Strategy for Education 2023-2027* is designed to enhance students' digital competencies

and expedite the adoption of digital tools in education (Department for Digital, Culture, Media & Sport, 2022). Key goals include developing a robust digital education ecosystem, improving digital citizenship and skills, and providing the educational community with sustainable digital resources. Additionally, France's *National Strategy for AI*, a component of the *France 2030* initiative, focuses on the advancement of AI technologies. This strategy reflects France's ambition to be a leader in AI, integrating AI across various sectors and addressing the ethical and societal implications of AI development.

Germany: The Federal Government's High-Tech Strategy 2025 encapsulates Germany's digital transformation strategy (Invest in Cote d'Azur, 2023). This strategy aims to position Germany as an innovation leader by leveraging research and high-tech advancements to address societal challenges and ensure sustainable economic growth. It highlights Germany's commitment to technological progress and the government's dedication to maintaining the country's status as an innovative powerhouse. The strategy targets critical areas such as health, sustainability, climate action, mobility, and digitalization, demonstrating a comprehensive approach to integrating advanced technologies into the German economy and society.

United Kingdom: The *UK's Digital Strategy*, released by the Department for Digital, Culture, Media & Sport in 2022, aims to foster a more inclusive, competitive, and innovative digital economy through digital transformation. It addresses essential aspects such as digital infrastructure, data management, regulatory frameworks, innovation ecosystems, digital skills and talent development, financing digital growth, and applying digital technologies to strategic priorities like productivity, public services, and achieving net-zero objectives (European Commission, 2023). This strategy presents a clear vision for enhancing the UK's global standing in the digital and technology sectors. Digital transformation strategies across various countries share a common emphasis on leveraging digital technology for economic growth, societal development, and global competitiveness. African countries, particularly Kenya and South Africa, focus on digital inclusion and infrastructure. In the Americas, the US and Brazil combine private sector leadership with policy support. In the Asia-Pacific region, countries like China, Singapore, and South Korea feature government-led initiatives. Australia and New Zealand prioritize digital skills and rural connectivity, reflecting each region's unique socioeconomic

contexts and digital readiness. In Europe, the UK, Germany, and France integrate public-private partnerships with innovation. These variations underscore each region's unique socioeconomic contexts and digital readiness.

3.2 Governance frameworks, mechanisms, and steps for the digital transformation of TVET

Digital transformation necessitates significant changes in the traditional mindset and core practices of TVET institutions, requiring a fundamental reimagining of their value propositions (Piepponen et al., 2022). Given the comprehensiveness and complexity of digital transformation, it can be challenging to comprehend and articulate. In such circumstances, institutions must embrace and manage positive changes while fostering a culture open to entirely new ways of working (Iosad, 2020). This situation poses a significant challenge. However, it is widely understood that TVET actors must adopt a proactive and flexible approach to positively embrace digital transformation. Through practice and exploration, they can discover their optimal path forward.

The scope of TVET actors is extensive, encompassing macro-governance entities such as ministries and statutory bodies, meso-level advocates like trade unions, research institutes, and NGOs (UNESCO-UNEVOC, 2021a; UNESCO-UNEVOC, 2021b), and micro-level implementing bodies such as TVET institutions and enterprises (UNESCO-UNEVOC, 2021c). This subsection focuses on the governance frameworks, mechanisms, and steps for the digital transformation of TVET, with particular emphasis on the micro-level implementing bodies (i.e. TVET institutions).

3.2.1 Key elements in the digital transformation of TVET governance

(1) Synthesized framework for the digital transformation of TVET governance

A study analyzing documents, theories, and research related to digital transformation practices and processes within TVET institutions developed a synthesized framework. This framework, comprising five pillars—policy, process, people, stakeholder, and infrastructure—serves as the foundation for a digital transformation framework. Table 3.1 highlights the diverse changes and characteristics within each pillar as TVET institutions progress towards high-performance in digital transformation (UNESCO, 2023).

Table 3.1 Transformation process of TVET institutions towards high-performance digital organization

Digital transformation framework	TVET institutions	Digital TVET institutions	High-performance digital TVET institutions
Policy		Organizational structure; Digital strategy	Governance and management procedures follow the digital format of the C-Suite
Process	Curriculum development; Instructional management; Information system management	Digital platform; Digital academic	Technological and innovative research be useful for industries and communities; Working process on a digital system; Learning process management by the digital system
People	Executive development; Teacher development; Student development	Digital leadership; Digital skills; Digital workforce	Digital intelligence quotient of learners; Digital readiness for labour market approaching of graduates; Digital leadership of executives; Digital competency of teachers and education personnel
Stakeholder		Digital stakeholder management	Digital cooperation with enterprises; Digital literacy and professional services to community and society
Infrastructure	Internet network; Buildings, classrooms, laboratories, workshops or farming; Learning sources and academic resource centres; Fundamental public utilities system	Digital infrastructure; Cloud computing; Internet of Things; Big data	Digital ecosystem

Source: UNESCO (2023, p. 34).

(2) Digital governance framework for the constantly changing work environment

Kähkipuro (2018) argues that information technology has evolved beyond a mere tool for assisting in various processes; it has become a crucial resource that enables organizations to gain a competitive edge. In the context of higher education, Kähkipuro proposes a governance framework comprising four clusters to manage the process of digital transformation more effectively and target digital resources more efficiently. These clusters are as follows:

- **Technical Cluster**: This cluster emphasizes traditional IT capabilities and the development of digital infrastructure. It encompasses capabilities best managed through methods akin to existing IT practices, such as cybersecurity. The primary objective is to ensure value for money while operating and developing the digital infrastructure.
- **Mainstream Digital Cluster**: This cluster consists of capabilities aimed at implementing the organization's official digital agenda, often derived from the main strategic plan. The primary drivers are business growth and differentiation. This cluster typically includes evident digital initiatives like supporting automation in administrative processes or enabling the use of common cloud services.
- **Evolving Digital Cluster**: This cluster is dedicated to transforming non-mainstream prospects into core business elements. It is a crucial part of an organization undergoing transformation that leverages technology as a source of growth and change. The focus here is on innovation and differentiation, and these capabilities are usually managed through a project or programme governance style.
- **Opportunistic Cluster**: This cluster includes capabilities that require further exploration before full integration. They are typically driven by individuals and represent the initial stage of the innovation pipeline, focusing on the growth of organizational knowledge.

Overall, the Technical Cluster involves basic IT infrastructure and related technologies; the Mainstream Digital Cluster addresses the organization's official digital plans and agendas; the Evolving Digital Cluster incorporates emerging technologies with the potential to become core business elements; and the Opportunistic Cluster provides a space for emerging and exploratory technological innovations. Kähkipuro's proposed systematic approach assists organizations in understanding and managing the constantly

changing work environment due to technological development, ensuring effective utilization of digital technology to enhance work efficiency and competitiveness

(3) Whole System Approach to the governance of TVET digital transformation

The Whole System Approach, under the Direction, Alignment, and Commitment (DAC) framework, is pivotal in facilitating effective collaboration among individuals to achieve collective accomplishments (McCauley, 2014). The DAC framework can serve as a vital tool for the efficient governance of TVET, given that Direction, Alignment, and Commitment are essential for collaborative efficacy and the attainment of shared objectives.

- **Direction**: This element of the DAC framework involves setting a clear strategy and goals for the digital shift within the TVET framework. It entails the identification and implementation of the most appropriate educational technologies, the evolution of pedagogical methods through technology, and the establishment of measurable indicators for the success of the transformation.
- **Alignment**: This component ensures that every digital transformation activity aligns with TVET's overarching aims, institutional objectives, and the needs of educators and learners. For example, if the primary objective of TVET is to enhance practical skills, the selected digital tools should facilitate and augment hands-on learning experiences.
- **Commitment**: This aspect underscores the importance of fostering a collective will and proactive participation from all stakeholders, including the administration, educators, learners, and others. For a successful digital transformation, it is crucial that all parties understand and support the purpose and benefits of the change. This may necessitate professional development for educators, introductory sessions for learners, and regular updates for all stakeholders.

By implementing the Whole System Approach through the DAC framework, TVET institutions can formulate a coherent vision for their digital transformation initiatives, ensure alignment with their strategic objectives, and cultivate a deep-seated commitment from all participants. As a result, TVET organizations can adeptly manage the change processes associated with digital innovation, thereby fostering an environment conducive to digital progress and securing significant, sustainable benefits for educators and learners.

(4) Governance mechanisms for the digital transformation of TVET

Jewer and van de Meulen (2022) reviewed the application of three governance mechanisms, including structure, process, and relationships, in their study on digital transformation.

- **Structure governance mechanism**: This pertains to the allocation of decision-making authority and responsibilities to facilitate coordination between business and IT. Traditional elements of organizational structure involved in digital transformation include IT expertise at the board of directors level, a Chief Information Officer on the executive committee, a Chief Operational Officer on the IT steering committee, and a risk officer. Two new elements are the Chief Digital Officer, a senior executive responsible for leading digital transformation, and Innovation Labs/Offices, which are mechanisms for developing and testing new ideas that can promote cross-departmental knowledge sharing and collaboration.
- **Process governance mechanism**: This refers to the formalization and institutionalization of strategic IT decision-making and IT monitoring procedures. Traditional governance mechanisms related to digital transformation include IT performance measurement. Two new elements are processes to integrate business and IT and agile methods. The former involves a series of steps or activities aimed at achieving coordination between business and IT, while the latter refers to a programme that emphasizes flexibility and agile pivots. Processes have become a driving factor in digital transformation.
- **Relationship governance mechanism**: This involves active engagement and collaboration between senior executives, IT managers, and business managers. Traditional elements of relationship governance related to digital transformation include co-location (IT and the business working together), executive management setting a good example (senior business leaders working with IT leaders), and IT leadership (IT leaders having the freedom to make IT decisions). Three new relationship mechanisms are cross-functional teams, technology-facilitated knowledge sharing, and leadership. Cross-functional teams are assembled to facilitate digital transformation, consisting of individuals from different departments or functional areas. Technology-facilitated knowledge sharing involves using technology as a tool to facilitate information and data

exchange and collaboration within or outside the organization. Leadership refers to the ability to guide, motivate, and support organizational members in the process of change and innovation during digital transformation.

3.2.2 Goals, steps, and stages for developing and implementing TVET digital transformation

(1) National governance goals of TVET digital transformation

To successfully advance the digital transformation of the entire TVET ecosystem, collaboration among stakeholders is essential. The following objectives, as outlined by IIEP-UNESCO Dakar (2022), ensure the feasibility of digital transformation across the ecosystem:

- **Establish a national network**: Comprising leaders, managers, and practitioners within the ecosystem, members should work collaboratively as ambassadors to support and drive the national digital transformation of the TVET and skills-development system.
- **Designate a national committee**: This committee, consisting of the department or institutions responsible for TVET, should coordinate the national agenda on the digital transformation of the TVET and skills-development system.
- **Compile a national report**: This report should detail the status of the digital transformation of TVET and the skills-development system, with a mechanism established to ensure its regular updates.
- **Develop an ICT and digital policy for TVET**: This policy should set the national agenda for the digital transformation of the TVET and skills-development system, with a mechanism implemented for regular updates.
- **Formulate a national guideline**: This guideline should instruct how to introduce/enhance ICT and digitalization in a TVET programme, with a mechanism established to ensure its regular update and adherence by all officially accredited TVET programmes.
- **Establish a roster of national experts and trainer-of-trainers**: This roster should focus on key issues related to the digital transformation of TVET and the skills-development system, with a mechanism for its regular update.

- **Equip youth and adults**: A significant number of youth and adults, including school graduates and informal sector adults, should be equipped with basic digital skills relevant to the labour market or specialized skills in digitalization and ICT.
- **Train teachers, instructors, and practitioners**: A substantial number of individuals within the ecosystem should be trained in mainstreaming digital and ICT skills necessary for their day-to-day work.
- **Celebrate an ICT and digital day in TVET**: Establish a mechanism to ensure its annual celebration.
- **Institutionalize or accredit a national centre of excellence**: This centre should focus on the digital transformation of TVET and the skills-development system.

(2) Steps for designing a digital transformation strategy

In the pursuit of a comprehensive digital transformation strategy for TVET governance, the foundational steps that guide the transformative process warrant careful consideration. The following six steps provide a structured framework for designing a robust digital transformation strategy (Reinitz & Grajek, 2021):

- **Step 1: Define the purpose**

  Initiating the digital transformation journey requires a clear understanding of its purpose. Institutions must articulate why they are engaging in digital transformation and identify the specific institutional goals, challenges, or needs the transformation aims to address.
- **Step 2: Identify the context**

  Context plays a pivotal role in shaping the necessity for change. Institutions must identify and analyze the contextual factors driving the need for digital transformation. This step ensures a nuanced understanding of the environment in which the transformation will unfold.
- **Step 3: Describe the impact**

  Anticipating change is crucial. Moreover, institutions should articulate how the digital transformation will impact the institutional value proposition. By aligning the transformation with the defined purpose, institutions can elucidate the expected changes that will contribute to overarching goals.
- **Step 4: Describe the outcomes**

Envisioning the future is essential to the digital transformation process. Institutions should outline the anticipated outcomes over specific timeframes, detailing what changes can be expected in the next six months and projecting developments over the next one to three years.

- **Step 5: Describe the outputs**

  Implementation lies at the heart of digital transformation. This step involves detailing the concrete outputs of the strategy, encompassing shifts in culture, workforce, and technology. Institutions should articulate what will be implemented and highlight the changes required for successful execution.

- **Step 6: List the inputs**

  To ensure the successful execution of the digital transformation strategy, institutions must identify the necessary inputs. This includes outlining the resources needed and specifying the digital transformation signals that will be relied upon or built to guide the transformative process. By cataloguing these inputs, institutions can proactively address the requirements for a seamless digital transformation journey.

These six steps collectively form a comprehensive approach to designing a digital transformation strategy tailored to the unique context and goals of TVET governance.

(3) A comprehensive guidance process for the digital transformation of TVET

In the field of digital transformation, Zaoui and Souissi (2020) propose a comprehensive guidance process specifically designed for institutions. This strategic framework includes several essential stages. First, institutions undertake an assessment phase to evaluate their current digital status and maturity. This step is crucial in identifying the specific needs and objectives that will guide the digital transformation. After the assessment, institutions articulate a strategic direction and vision for their digital transformation journey. This involves a detailed process of defining value propositions and refining business models, thereby establishing a clear and purposeful path. With the strategic vision defined, the next critical step is the creation of a detailed roadmap for implementing digital transformation. This roadmap acts as a guide, outlining key milestones and setting realistic timelines to facilitate the systematic execution of the transformation process.

Implementation, the core of digital transformation, requires a comprehensive approach. This includes the integration of advanced information and communication

technologies, the overhaul of business processes, the promotion of innovation in products and services, the enhancement of customer experiences, the implementation of organizational structural adjustments, and the cultivation of digital culture and capabilities within the institution.

The transformation journey does not end with implementation; continuous assessment and monitoring are essential. Institutions systematically evaluate the effects and impacts of digital transformation, promoting a culture of ongoing improvement and innovation to adapt to changing landscapes. Essentially, the guidance process proposed by Zaoui and Souissi represents a holistic and iterative approach, where assessment, strategic formulation, careful planning, implementation, and continuous evaluation form an interconnected and cyclical continuum, ensuring a dynamic and responsive progression towards digital maturity.

3.2.3 Maturity framework for digital transformation in TVET

To describe the maturity or development level of an organization's digital transformation, various terms such as digital development, digital adoption, digital readiness, digital maturity, digital transformation stage, digital capability, digital innovation, digital leadership, digital governance, and digital culture are used. Understanding an organization's digital maturity is not an endpoint; instead, appropriate measures and practices should be based on the level of maturity to enhance the organization's digital capabilities. Research suggests that organizations with higher digital maturity are nearly three times more likely to achieve above-average annual revenue growth and net profit compared to lower-maturity organizations (Gurumurthy & Schatsky, 2019). The tangible benefits of driving digital transformation have stimulated academic and industry research into digital maturity models or frameworks.

(1) Maturity framework for digital transformation in organizations

In the context of organizational digital transformation, particularly within businesses, numerous maturity models have been developed and are widely used (Seer Interactive, n.d.):

- **The McKinsey Digital Quotient (DQ) Model** assesses an organization's digital readiness across five dimensions: strategy, capabilities, culture, organization, and

digital maturity. It helps organizations identify their digital strengths and weaknesses, formulate a digital strategy, and prioritize digital initiatives.

- **The Capgemini Digital Maturity Model** evaluates an organization's digital maturity across six stages: Initiate, Experiment, Scale, Integrate, Transform, and Optimize. This model aids in assessing digital maturity and monitoring progress over time.
- **The Gartner Digital Business Maturity Model** analyzes digital maturity through five stages: Initiating, Experimenting, Scaling, Transforming, and Digital Leadership. It is designed to assess digital capabilities, shape digital strategy, and align business goals with digital initiatives.
- **The Digital Capability Framework by Deloitte** examines digital maturity across four categories: Strategy, Customer, Operations, and Culture. It assists organizations in evaluating their digital capabilities, identifying gaps, and setting digital priorities.
- **The Optimizely Digital Experience Maturity Model** assesses digital maturity across five levels: Ad-hoc, Basic, Intermediate, Advanced, and Leading. It focuses on evaluating digital experience capabilities, formulating digital strategies, and optimizing digital experiences.

Overall, the discussed digital maturity models offer valuable insights into organizational digital transformation, particularly their ability to assess digital capabilities, identify gaps, and prioritize digital initiatives. While each model provides a unique approach and framework, they share common features such as structured progression, a focus on key digital aspects (strategy, culture, and capabilities), and alignment with business goals. These models can serve as a reference for educational institutions, given their adaptability and comprehensive assessment methods.

(2) Maturity frameworks for digital transformation in higher education

- **Digital Development Index**

Specialized frameworks for assessing digital transformation maturity in educational institutions, including higher education and TVET, are scarce. In response to this, the Secretariat of the Global MOOC and Online Education Alliance developed the Digital Development Index specifically for global higher education. This index evaluates the

level of digitalization in higher education across various countries, compares developmental disparities, predicts future potential, and explores relevant development strategies. The index, developed based on five principles—systematic, universal, objective, operable, and developmental—centres on the core concepts of higher education digitalization: digitized education, digitalized administration, digital management, and digital security. It comprises four primary indicators, 10 secondary indicators, and 18 specific measurement indicators, each reflecting different aspects of higher education's digital development (Global MOOC and Online Education Alliance, 2023).

To advance digital governance maturity in higher education, including TVET, enhancements can be made across five dimensions: (1) Leadership, Vision, and Commitment to Change; (2) Policy Development; (3) Governance and Regulatory Frameworks; (4) Digital Infrastructure and Enabling Technologies; and (5) Funding and Financing (Grech, 2023).

In the Leadership, Vision, and Commitment to Change dimension, effective innovation and digital education and training goals necessitate robust leadership at all levels—political, institutional, organizational, or company—within the TVET ecosystem. Government commitment to digital transformation and multi-sector collaboration in executing transformation plans are vital for successful implementation.

In the Policy Development dimension, the need for TVET's digital transformation within government policy frameworks is emphasized. Policy development should encompass key areas such as infrastructure, industry and economic policies, digital skills development policies, and policies related to job learning opportunities. Policy documents may take the form of national strategies to guide decision-making.

The Governance and Regulatory Frameworks dimension notes that regulatory frameworks for 'digitalization' are still nascent and pose a global challenge. Digitalization blurs the boundaries between TVET and higher education, hastening the hybridization of higher education. In this era of diversity and complexity, quality assurance must adapt to new requirements such as micro-credentialing, Social Security Information (SSI), and digital certification. Future quality assurance will be more private sector-driven, open, and digital.

The Digital Infrastructure and Enabling Technologies dimension underscores the need for key decision-makers at the policy, TVET, and labour market levels to recognize technology as a significant driver of socioeconomic and cultural change. The successful

application of emerging technologies such as VR, AR, Mixed Reality (MR), AI, and blockchain in TVET digital transformation, along with related government commitments and interests, will directly influence the success of digital transformation.

Lastly, the Funding and Financing dimension highlights the substantial demand for funds in each component of the TVET ecosystem, as infrastructure and related technologies require significant investment. Funding models must be more flexible, and transparency in the funding process signifies a higher level of digitalization.

- **Maturity Assessment Framework for Digital Transformation in Higher Education**

Marks et al. (2020) proposed a framework to assess the digital transformation maturity of higher education institutions. This framework highlights a significant discrepancy between respondents' perceptions of digital transformation maturity and the core criteria. It acknowledges the numerous challenges higher education faces in digital transformation, offering guiding standards and an assessment system to help institutions identify strengths and weaknesses and align these with major processes.

The proposed digital maturity assessment framework evaluates an organization's digital transformation maturity based on five key criteria:

1. **Vision and Strategy:** Does the organization have a suitable digital vision and strategy, supported by leadership communication and attention?
2. **Talent Skills and Knowledge:** Does the organization have the necessary talent, skills, and knowledge to support its vision, products, and services?
3. **Process Control and Digital Technology:** Does the organization possess the appropriate process controls and digital technology to support its operations?
4. **Technology and Infrastructure:** Does the organization have the right technology and infrastructure, along with the capabilities for development, management, and delivery?
5. **Customer Understanding and Communication:** Does the organization have effective methods to understand and communicate with customers in a digital environment?

This framework can be used to measure each major process equitably, with institutions having the option to assign different weights. The framework functions like a scorecard, identifying strengths and weaknesses in each major process and maturity

criterion, enabling users to easily identify the weakest processes in terms of digital transformation. Consequently, it can assist higher education institutions in tracking their progress in digital transformation and conducting regular benchmarking tests.

In summary, digital maturity models often vary in industry specialization, scope, and assessment focus. Some models concentrate on specific industries, providing a deeper understanding and more accurate assessment, making them more effective for those industries. Additionally, different digital maturity models have unique scopes; some can assess the overall digital maturity of organizations comprehensively, aiding decision-makers in determining improvement directions. Others may focus more on specific areas, providing a more in-depth analysis for effective resolution of issues in a single business domain. In terms of assessment focus, some models may prioritize processes and personnel, while others may emphasize the quality of outputs and services.

3.3 TVET ecosystem in digital transformation

3.3.1 Components and stakeholders of the TVET ecosystem in digital transformation

(1) Digital transformation of the TVET ecosystem's main components

TVET was initially established to equip young individuals with the necessary skills for workforce entry, a mission it continues to fulfil in numerous developing countries. However, the advent of a global technological revolution has redirected TVET's objectives towards providing higher education levels and advanced technological skills. The TVET structure comprises three primary components: (1) General Education, which lays the foundation for vocational skills; (2) Initial Training Systems (ITS), encompassing TVET from an early age; and (3) Continuing Training Systems (CTS), focusing on continuous vocational learning to meet the job market's evolving needs (US Agency for International Development, 2014). These components must adapt and evolve in response to digital transformation, aligning with changes across the entire TVET ecosystem.

- **General Education for Digital Transformation**: General Education, the bedrock of TVET, imparts students with essential basic skills and knowledge. In the digital transformation context, General Education can integrate foundational digital skills such as information literacy, basic computer operations, and

cybersecurity awareness, thereby setting the stage for further specialized skills learning. It is imperative to ensure that all students acquire the necessary digital foundational skills, necessitating the integration of digital skills and thinking from the most fundamental educational level.

- **Initial Training Systems for Digital Transformation**: ITS generally covers TVET's initial stages and can significantly benefit from digital tools and platforms, thereby rendering learning more flexible and personalized. Furthermore, technologies such as simulation software and VR can offer a safer and more controlled environment for learning specific skills. The integration of advanced digital tools and methods at the initial training stage can enhance education's quality and efficiency. This necessitates that educators and trainers possess the relevant skills and resources for effective tool utilization.
- **Continuing Training Systems for Digital Transformation**: Given the rapid changes in the work environment and technology, lifelong learning has become indispensable. Digital transformation is particularly vital in CTS as it provides flexible learning methods, enabling working individuals to balance work and study. Moreover, it facilitates customized and targeted training. It is essential to establish an environment that supports lifelong learning and skills upgrading to maintain workforce competitiveness. Digital technology offers tools for swift adaptation to market and technological changes, necessitating the development of effective online learning resources and support systems.

Overall, the digital transformation of the TVET ecosystem necessitates integration and innovation at every stage, from basic education to vocational training and lifelong learning. This is not merely about introducing new technologies but about effectively utilizing these technologies to enhance education's quality, adaptability, and accessibility, as well as ensuring that all relevant individuals can keep pace with this change. This requires a collaborative effort from policymakers, educational institutions, and industry partners to construct a TVET ecosystem that supports and promotes digital transformation.

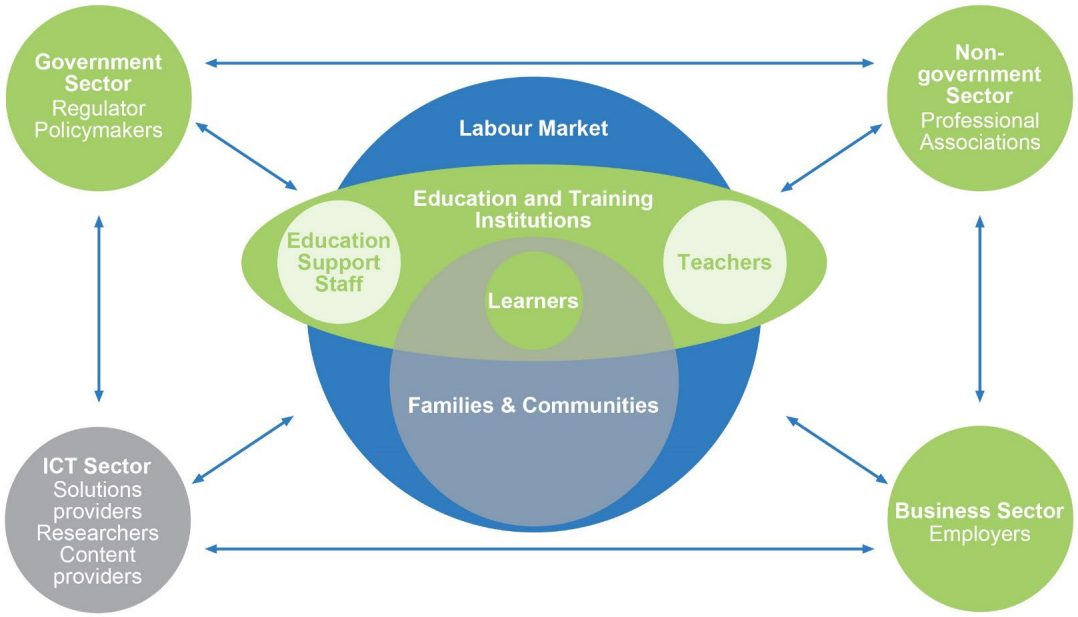
(2) Stakeholders of the TVET ecosystem in digital transformation

The discussion of the TVET ecosystem inevitably leads to the skills ecosystem. The TVET ecosystem primarily comprises formal institutions, including technical and vocational schools, polytechnic institutes, and training centres. These institutions offer

structured courses that integrate theoretical knowledge with practical training in specific technical fields (Salleh & Sulaiman, 2020). Conversely, the skills ecosystem represents a broader interpretation of the TVET ecosystem. It encompasses not only learning pathways provided by formal institutions but also a variety of non-traditional educational institutions. These include apprenticeships, on-the-job training, online courses, vocational training centres, and entrepreneurship development programmes (ILO, 2020).

In advancing the digital transformation of TVET, it is crucial to consider stakeholders from both the TVET ecosystem and the skills ecosystem. Figure 3.1 illustrates the typical stakeholders in the TVET and skills-development ecosystem. These stakeholders should be correctly identified and understood when promoting the digital transformation of TVET (Grech, 2023). Stakeholders involved in driving the digital transformation of TVET include not only education and training institutions' education support staff, teachers, and learners but also the labour market, families and communities, the government sector, the non-government sector, the business sector, and the ICT sector. The latter is closely related to digital transformation as solutions providers, researchers, and content providers.

Figure 3.1 Stakeholders in TVET and the skills-development ecosystem



Source: Grech (2023, p.11).

3.3.2 Various TVET models in the digital transformation of the TVET ecosystem

(1) Three distinct European TVET models in the digital transformation of the TVET ecosystem

From a historical and comparative perspective, Wolf (2020) identifies three fundamental types of classic European TVET models: the Market Type, the Bureaucracy Type, and the Traditional Type. Each of these plays a unique role in the digital transformation of the TVET ecosystem.

- **Market Type**

Often referred to as the liberal market economy model, the Market Type is characterized by a TVET system directly influenced by labour production factors and the signals of qualifications required by the labour market. Predominantly seen in countries like the UK and Australia, TVET in these nations reflects the needs of the private market, driven by industries and firms. Industry skill councils identify the required occupational qualifications, with private industries voluntarily funding workers' training and apprenticeships. The state typically subsidises 'high-risk' youth to enhance their access to labour education and training, as well as funding necessary research on occupational demands and National Qualifications Frameworks (NQFs). This model emphasizes market-driven educational supply and can rapidly adapt to technological changes. However, its flexibility might lead to instability in educational quality and long-term career planning. Encouraging private sector and industry involvement in training plans could accelerate the adoption of technological tools and methods.

- **Bureaucracy Type**

The Bureaucracy Type, also known as the state-regulated bureaucratic model, is governed by legal regulations enforced by the state or its bureaucratic institutions. This model is prevalent in countries such as France, Italy, Sweden, and Finland, where the national education system defines, provides, and funds TVET. However, this model often suffers from an overemphasis on theoretical curricula and a lack of practical workplace exposure, leading to a failure to meet local labour demands. While it ensures nationwide standards and quality, it may lack the flexibility and responsiveness needed to adapt to market

changes. Despite these limitations, this model provides a stable and predictable environment conducive to long-term planning and substantial investment in digital infrastructure and resources.

- **Traditional Type**

The Traditional Type, commonly known as the dual system model, operates based on established, customary, and legitimate practices. This model, exemplified by countries such as Germany, Austria, Switzerland, Denmark, and Norway, involves a wide range of public and private stakeholders in the design, development, and implementation of TVET. The dual system model fosters strong public-private collaboration, with enterprises funding apprenticeship training and state agencies supporting TVET institutions. However, its primary weakness lies in the limited number of apprenticeship openings in enterprises and the high cost of TVET compared to general secondary education. Despite these challenges, its combination of institutional education and corporate training provides a solid foundation for digital transformation. This model encourages continuous learning and skill updating, which are essential for maintaining competitiveness in a rapidly changing technological landscape.

(2) TVET models from a comparative political economy perspective

Wolf (2020) examines the various organizational possibilities for TVET within advanced industrial democracies from a comparative political economy perspective. The study presents four potential classifications based on two dimensions: 'public commitment to vocational training' and 'involvement of companies in initial vocational training'. From Table 3.2, three of these classifications correspond with previously mentioned models: the Statist Skill Formation System aligns with the Bureaucracy Type, the Liberal Skill Formation System corresponds to the Market Type, and the Collective Skill Formation System is similar to the Traditional Type.

From a comparative political economy perspective, a fourth category, termed the Segmentalist Skill Formation System, emerges as a new type. This system serves as an alternative to the Market Type, also known as the Segmental Model, which is characterized by significant corporate investment in initial training. In this model, companies design training programmes to align specifically with their recruitment needs and internal career development objectives. It is crucial to distinguish this model from

the collective approach. For instance, in Japan, large corporations focus solely on their unique requirements when training apprentices, often neglecting the broader needs of their entire sector, such as the automotive industry.

Table 3.2 Various possibilities for organizing TVET in advanced industrial democracies

Public commitment to vocational training	High	Statist skill formation system e.g. France, Sweden, …	Collective skill formation system e.g. Germany, Denmark, Austria, Switzerland, …	Cooperative model of TVET (market/state interplay)
	Low	Liberal skill formation system e.g. USA, Great Britain, …	Segmentalist skill formation system e.g. Japan	Market model of TVET (market mechanisms interplay)
		Low	High	
		Involvement of companies in initial vocational training		

Source: Wolf (2020, p. 65).

Companies operating under this model invest heavily in initial training and customize this training to meet their specific needs, potentially leading to improved skill matching. In the context of digital transformation, this implies that businesses can develop employees with precise digital skills to meet their rapidly evolving technological demands. This model requires companies to take on greater responsibility in TVET, implying that businesses must invest not only in technology and tools but also in talent development. However, as this model relies on corporate investment, it may result in uneven resource distribution, particularly among different companies and industries. Larger corporations may be able to provide high-quality digital training, while smaller enterprises may struggle, thereby exacerbating skill and opportunity inequalities.

Consequently, policymakers may need to consider strategies to encourage corporate investment in training while ensuring that all individuals have access to high-quality digital skills training. This could involve incentive measures, setting minimum training standards, or promoting industry-wide collaboration. In summary, the Segmentalist Skill Formation System within the comparative political economy framework offers a unique approach to organizing TVET, especially in the era of digital

transformation. However, it also presents challenges that require careful consideration and strategic planning from various stakeholders.

3.3.3 A governance framework for the digital transformation of the TVET ecosystem

At the national level, policies for reforming the entire TVET ecosystem should reflect a broader economic, social, and political context. When assessing the reform of the TVET ecosystem policy, a framework of six broad questions is proposed. These questions encompass the background of the national TVET policy, the current governance structure and participation, the main inputs and service provision in the system, the financing and budget level and mechanisms, the policies promoting access and relevance, and the evidence of the main outcomes, impact, and sustainability of the existing policies (US Agency for International Development, 2014). These analyses assist in determining the appropriate policy for a country, which should align with the country's broader policy framework, thereby laying a foundation for successful TVET programmes. To aid policymakers, educational institutions, and stakeholders in better understanding and addressing the challenges and opportunities encountered in the governance process of the TVET ecosystem in the digital age, this six-question framework can be specifically understood as follows:

- **What is the national context of TVET policy, especially in the context of digital transformation?** When considering the nation's socioeconomic, regulatory, and policy environment, particular attention should be given to the trends and impacts of digital transformation. Evaluate how the TVET system aligns with the nation's digital strategy and goals, and identify which socioeconomic factors might facilitate or hinder this process.
- **What role do the current TVET governance structure and policy participation play in digital transformation?** Analyze how different institutions and stakeholders influence decision-making, implementation, and oversight in the digitalization process of TVET. Explore how digital tools and platforms can be utilized to improve governance structures and promote broader and more effective stakeholder engagement.

- **What are the new changes in the main inputs and service provision in the system during digital transformation?** Examine how digital technology impacts and transforms teaching resources, classroom facilities, institutional management, and service provision. Discuss how to enhance the efficiency and quality of the TVET system through digitalized curricula and online learning platforms.
- **What impact does digital transformation have on the financing level and mechanisms of TVET?** Analyze the impact of digital transformation on TVET financing needs and explore new financing mechanisms such as public-private partnerships, international aid, or digital currencies and how they support the digitalization process of TVET. Consider how to ensure transparency and fairness in financial allocation, especially regarding technological investments.
- **In the context of digital transformation, what policies promote access and relevance?** Identify policy measures that can ensure all learners, including marginalized groups, have access to high-quality digital TVET courses. Explore how collaboration, curriculum design, scholarships, and digital apprenticeships can enhance the relevance and attractiveness of TVET courses.
- **What is the existing evidence of the main outcomes, impacts, and sustainability of policies in digital transformation?** Investigate the specific outcomes and impacts of TVET policies and practices after the introduction of digital transformation, such as enhanced digital skills among students, increased labour market adaptability, and strengthened community participation and innovation capacity. Additionally, assess the long-term sustainability of these policies and their potential impact on the future labour market.

3.4 Summary

This chapter examines the intricate strategies, governance frameworks, and processes of digital transformation in TVET at various levels. It provides a critical evaluation of the transformative influence of digitalization on TVET governance, underscoring the necessity for ongoing adaptation, inventive policymaking, and collaborative efforts from stakeholders to ensure TVET's relevance and effectiveness in the ever-evolving digital era.

The development of governance strategies in TVET institutions is of paramount importance. These strategies ought to be in line with the guidelines provided by

international organizations such as UNESCO, the ITU, and the World Bank, regional entities like the ASEAN, the EU, and the AU, as well as national policies. Such alignment guarantees that the strategies are in harmony with the wider objectives of improving the quality, accessibility, and flexibility of education through digital technology. TVET governance effectiveness encompasses a variety of approaches, including frameworks, mechanisms, principles, and stages of digital transformation. The chapter highlights the significance of comprehensive governance structures that integrate digital technologies, promote innovation, and address the challenges of digital transformation. The adaptation and evolution of governance structures in TVET are crucial to navigate the rapidly changing digital landscape.

A key takeaway for stakeholders is the collective effort required from various parties, including governments, educational institutions, and the private sector, for the digital transformation in TVET. This collaboration is vital for the successful implementation and sustainability of digital strategies in TVET.

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Chapter 4

Digital Transformation of TVET Programmes and Curricula

Qianmin Lin and Wenming Yang

Academic programmes and curricula, the fundamental pillars of instruction within Technical and Vocational Education and Training (TVET) institutions, are currently undergoing significant evolution due to emerging digital technologies. This chapter explores in detail the digital transformation of TVET programmes and their corresponding curricula, discussing the underlying rationales, strategic frameworks, methodological approaches, and supportive instruments driving this transformative process.

4.1 Digital transformation of TVET programmes

4.1.1 Rationale of the digital transformation of TVET programmes

Digital transformation significantly impacts multiple sectors. In education, particularly TVET, it has led to notable changes in training objectives, development models, delivery

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X. Yang & W. Yang (Eds.), *Digital Transformation in Global TVET: Methodology and Practices*. UNESCO Chair on Digitalization in TVET.

patterns, learning pathways, and learning scenarios. TVET institutions must digitally transform the design and delivery of programmes in response to five key areas of change.

(1) TVET training objectives transition from 'specialized' to 'versatile'

The trend towards broadening training objectives from highly specialized to versatile skill sets in TVET programmes reflects the dynamic and evolving demands of the workforce in the digital era. The future job landscape is expected to operate systematically, necessitating a diversified toolkit that includes advanced techniques, technologies, and a particular focus on digital and business marketing skills (World Economic Forum, 2020). While the past employment paradigm valued specialists with in-depth knowledge or skills in a specific area, the present and future require professionals with multiple specializations and a generalist's understanding of other fields. Such multifaceted talents are increasingly sought after in the labour market (DevOps Institute, 2020; DeKoninck & Bridge, 2023). By embracing versatility and anchoring it within the digital transformation framework, TVET programmes equip students with a comprehensive skill set, enhancing their employability across various sectors. This strategic move aligns with a broader vision of preparing learners for success in technologically sophisticated and digitally inclusive work environments, marking a pivotal journey into TVET's digital future.

(2) TVET programme structure shifts from 'independent' to 'clustered'

The structuring of TVET programmes is transitioning from solitary, independent modules to a more integrated, clustered approach. This shift recognizes that the multifaceted challenges of preparing a workforce for an evolving global economy cannot be sufficiently addressed by isolated disciplines. This new model is characterized by two main elements. First, it encourages interdisciplinary development. The fusion of diverse academic fields is crucial as it makes education more relevant to real-world situations and provides students with the extensive skill sets employers demand. Illustrating this trend is China's *Declaration on the Development of New Liberal Arts*, issued in November 2020, which advocates for the synergistic blend of digital technologies, such as AI and big data, with liberal arts. It calls for the creation and advancement of pioneering liberal arts programmes and strives for thorough interdisciplinary synthesis with sectors of science, engineering, agriculture, and medicine (Ministry of Education of China, 2020).

The second element involves promoting programme clusters. This strategy effectively catalyzes interdisciplinary sectors, broadening students' knowledge spectrum and forging expansive career trajectories, a practice supported in various developed regions (Li, 2019). In China, the clustering of TVET programmes aims to consolidate established, high-employment programmes with similar, yet distinct, ones. The goal is to amalgamate educational resources and enhance the quality of the educational offerings (Zhang & Lu, 2023). It is anticipated that such TVET programme clusters will continue to grow, pooling resources and fostering students with stronger employability and professional competencies.

(3) TVET programme delivery turns from 'institution-based' to 'ecosystem-collaborative'

Traditionally, TVET or work-based training institutions have independently developed their educational or training programmes, tailoring them to their specific faculties and instructional environments. However, the digital era emphasizes collaboration, with TVET institutions increasingly engaging with private sector partners and research entities to co-develop their programmes. As noted by UNESCO-UNEVOC (2020), this collaborative TVET ecosystem significantly drives innovation within these educational institutions.

The reasons behind this shift are manifold, including aligning the skills produced by TVET programmes with stakeholders' varied needs, thus enhancing the relevance and efficiency of TVET programmes. By forming a digital ecosystem spanning governments, private sectors, trade unions, peer TVET institutions, universities, and research entities, TVET can seamlessly integrate with regional socioeconomic development strategies and talent requirements. Moreover, digital ecosystems offer a platform for skill needs from the private sector to directly inform TVET programme development, resulting in more pertinent learning experiences that strengthen students' technical skills and employability. Such cross-sectoral TVET ecosystems also facilitate the exchange of resources and knowledge, encouraging collaboration and partnerships, optimizing resource use, and elevating educational outcomes. In terms of adaptability, a collaborative model of TVET programme delivery offers heightened resilience, allowing TVET institutions to combine their capabilities and create a robust network that can deftly navigate market changes.

(4) Programme learning pathways transition from 'standardized' to 'flexible'

TVET learning pathways, traditionally regarded as 'standardized' in many contexts, are undergoing a significant transformation towards increased flexibility. Flexibility has been a crucial consideration for TVET since the onset of the COVID-19 pandemic, as learners and workers strive to maintain a work-life balance. The advancement of digital technologies has been a pivotal factor in this transition, enabling the adoption of micro-credentialing and micro-learning that cater to diverse learning needs. Teachers/trainers can create new digital instructional materials without deep expertise in creative tools. Online learning platforms are expanding access to education via remote and hybrid modalities, providing a wider range of engagement options for TVET students and teachers. Blockchain technologies are designed to support autonomy and security, allowing any student to receive acknowledgement for completing learning experiences (Oliver, 2016; UNESCO, 2022).

Customized and flexible learning experiences are now accessible to all lifelong learners, thanks to the advancement of educational technologies and the introduction of micro-credentials. In formal education, micro-credentials offer targeted, industry-specific workforce preparation, enabling graduates to be immediately ready for the workforce. These credentials can also diversify degree programmes, providing learners with options to align their experiences with their interests and needs (Hijden & Martin, 2023; HolonIQ, 2021; UNESCO, 2022; UNESCO-ICHEI, 2022). For workers seeking to upskill, micro-credentials offer a solution by allowing them to focus on highly specific subjects directly relevant to their jobs, thereby avoiding unnecessary or unengaging material. This shift towards more flexible and personalized learning pathways signifies a significant transformation in the delivery of TVET programmes.

(5) Programme learning/training scenarios shift from 'physical' to 'physical-virtual blended'

The evolution of TVET from traditional classrooms to a blend of physical and virtual environments is a reflection of modern technological and educational advancements. This transformation is pivotal as it eliminates geographical constraints, thereby broadening the scope for a larger audience to participate in TVET. The integration of digital platforms allows TVET to provide a variety of learning and training opportunities that cater to

diverse learning styles and speeds, effectively meeting the varied needs of its learners. Virtual training not only reduces costs by diminishing the need for extensive physical infrastructure and related expenses, but it also allows learners to interact with course material without the time spent commuting.

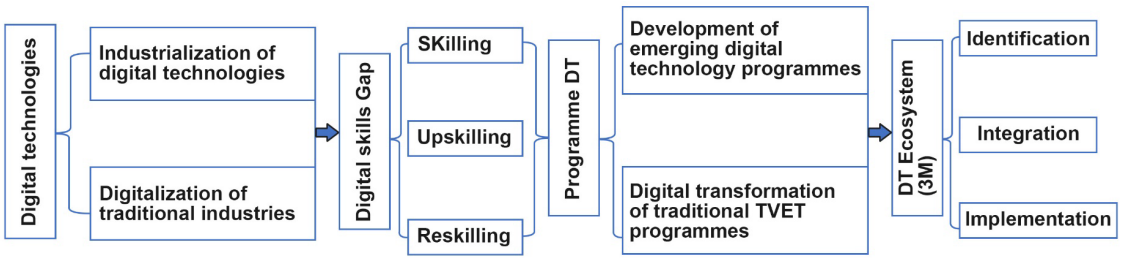
Furthermore, the amalgamation of physical and virtual learning environments facilitates real-time progress tracking and personalized feedback, promoting an agile learning process where students can quickly identify and address skill gaps. This feature is particularly useful for technical training involving high-risk tasks, as learners can initially engage in virtual simulations to master complex operations in a risk-free environment. Additionally, this blended approach fosters a commitment to lifelong learning by providing a flexible framework for continuous skill development, which can be balanced with work and other personal obligations.

Overall, the integration of physical and virtual training in TVET combines the advantages of both formats: practical experience from physical training and accessibility, flexibility, and personalized learning experiences from virtual training.

4.1.2 Framework for the digital transformation of TVET programmes

Industries 4.0 and 5.0, powered by emerging digital technologies, significantly influence digital transformation across various sectors (see Figure 4.1). They induce paradigm shifts in industrial operations, prompting the adoption of advanced digital technologies to improve governance, operations, productivity, and customer experiences.

Figure 4.1 Flowchart of the digital transformation of TVET programmes



Source: Authors, adapted from UNESCO-UNEVOC (2021).

The digital transformation propels the digital economy in two directions: the industrialization of digital technologies and the digital transformation of traditional

industries. Both aspects necessitate the expertise of skilled digital professionals. The supply of this expertise is enabled by comprehensive digital skilling, upskilling, and reskilling driven by the digital transformation of TVET programmes.

Consequently, the digital transformation of TVET programmes can be implemented in two dimensions: the development of programmes based on emerging digital technologies and the digital transformation of traditional TVET programmes. These correspond to the two directions of the digital economy. Both dimensions require support from the 'Digital Transformation Ecosystem', encompassing the '3M'—Macro-level institutions, including national or regional governments and TVET coordination agencies; Meso-level institutions, including industrial associations, trade unions, TVET associations, and private sectors; and Micro-level institutions, including TVET institutions, work-based learning (WBL) institutions, and training centres (UNESCO-UNEVOC, 2021).

The '3M' institutions each play distinct roles and contribute differently to the three approaches of TVET programme digital transformation, namely, 'Identification, Integration, and Implementation' (UNESCO-UNEVOC, 2021, p. 8). The identification of digital skills required by various sectors involves mapping and recognizing the evolving digital skills needed in different industries. This task will be undertaken by various institutions, such as government agencies, private sectors, and TVET institutions. The integration of digital skills into TVET programmes refers to the inclusion and development of digital skills in TVET programmes and courses, primarily by TVET institutions and the private sector. The implementation of digital skills refers to the teaching and learning of digital skills by leveraging digital education technologies and pedagogies in TVET, which will be carried out by teachers/trainers from TVET institutions or WBL companies.

4.1.3 Approaches to the digital transformation of TVET programmes

There are several approaches to the digital transformation of TVET programmes. The key approaches are presented below:

(1) Establishment of the digital transformation ecosystem

Creating a digital ecosystem is a fundamental step towards ensuring successful digital transformation in TVET institutions. As industries increasingly rely on digital technologies, a digital ecosystem can ensure that TVET students acquire the necessary digital skills, keeping their education and training relevant and enhancing their competitiveness in the job market. A digital ecosystem can foster increased collaboration between governments, TVET institutions, private sectors, and research institutions, leading to more effective education, idea exchange, greater innovation, and robust linkages between TVET institutions and industries. The digital ecosystem can be used for skill development beyond the traditional curriculum, offering students opportunities to explore and learn digital skills and transversal skills. The digital ecosystems can take various forms. For instance, by the end of 2023, 18 joint industrial schools were established at Shenzhen Polytechnic University, China, in collaboration with top companies across different sectors (Shenzhen Polytechnic University, 2023).

(2) Virtual simulation training centres

Virtual simulation training centres leverage digital transformation to enhance education, align training with industry needs, and prepare learners for the demands of modern workplaces. These centres address some of the most significant challenges in traditional TVET training and are increasingly viewed as the future of TVET as they aim to bridge the learning gap and promote excellence in TVET sectors. Virtual simulation training centres can enhance practical skill acquisition by offering learners an environment where they can gain hands-on practical experience, bridging the gap between academic knowledge and practical skills, familiarizing them with the use of state-of-the-art technologies, and preparing them for the future of work, thereby enhancing their employability. They provide a risk-free environment in which learners can practice without fear of causing harm or accidents, reduce the cost and need for physical materials, offer the flexibility to learn anytime and anywhere as per individual needs, and enhance inclusion and diversity by offering customized services to suit various learners with diverse needs, interests, and abilities, promoting inclusion and diversity in TVET. For example, according to the *Notice on the Key Tasks of Accelerating the Development and Reform of the Modern TVET System* (Ministry of Education of China, 2023), by 2025, approximately 200 national first-class virtual training bases will be established, and about 1,000 regional model virtual training bases will be established in different provinces or

cities, aiming to promote the innovation of practical teaching and training models in TVET.

(3) Virtual teaching and research centres

A virtual teaching and research centre is a novel grassroots organization that utilizes modern information and communications technology (ICT) to overcome temporal and spatial constraints. It conducts both online and offline teaching research and practice activities in a flexible and diverse manner. Characterized by the digital era, this community is committed to leading and promoting innovation and transformation in TVET (Zhu, 2023). The centre operates through an ICT platform, facilitating collaborative teaching and research. It embodies the principles of openness, accumulation, co-development, and sharing (Zhan et al., 2022).

In essence, a virtual teaching and research centre can enhance the quality of TVET education and research by expanding access to resources, fostering flexible professional learning, aiding professional growth, and nurturing a collaborative and innovative environment.

(4) Programme teaching and learning databanks

A 'programme teaching and learning databank' in TVET acts as a comprehensive digital repository of resources related to specific educational programme content. These databanks are typically developed by various stakeholders, including national and local governments, TVET institutions, and the private sector, often through collaborative efforts. For instance, in China, 1,014 national and provincial programme teaching and learning databanks were developed and shared on the 'China National Smart TVET Platform', benefiting over 11,300 TVET institutions domestically and internationally (Zhang & Lu, 2023).

These databanks play pivotal roles in TVET. They store curriculum content such as syllabuses, course outlines, teaching materials, assignments, assessments, and multimedia resources for various programmes or courses, thereby streamlining the instructional planning and delivery process for educators. Additionally, they provide access to a wide array of learning materials, catering to diverse learning styles, including digital textbooks, videos, online lectures, interactive simulations, and quizzes. Moreover, they serve as

archives for best practices, successful teaching methods, assessment tools, and research resources, fostering collaboration among educators across different disciplines or institutions. Furthermore, these databanks promote resource sharing, collaboration, and lifelong learning for students, enabling them to access materials for reference or further study beyond classroom hours.

A well-maintained and regularly updated programme teaching and learning databank contributes to ensuring quality education and fostering a culture of knowledge sharing and continuous learning in the field of TVET.

(5) Online learning/e-learning platforms

An online learning platform in TVET serves as a digital environment that facilitates the delivery of educational content and manages the learning process over the Internet. It accommodates various forms of distance education, blended learning, and supplemental classroom activities.

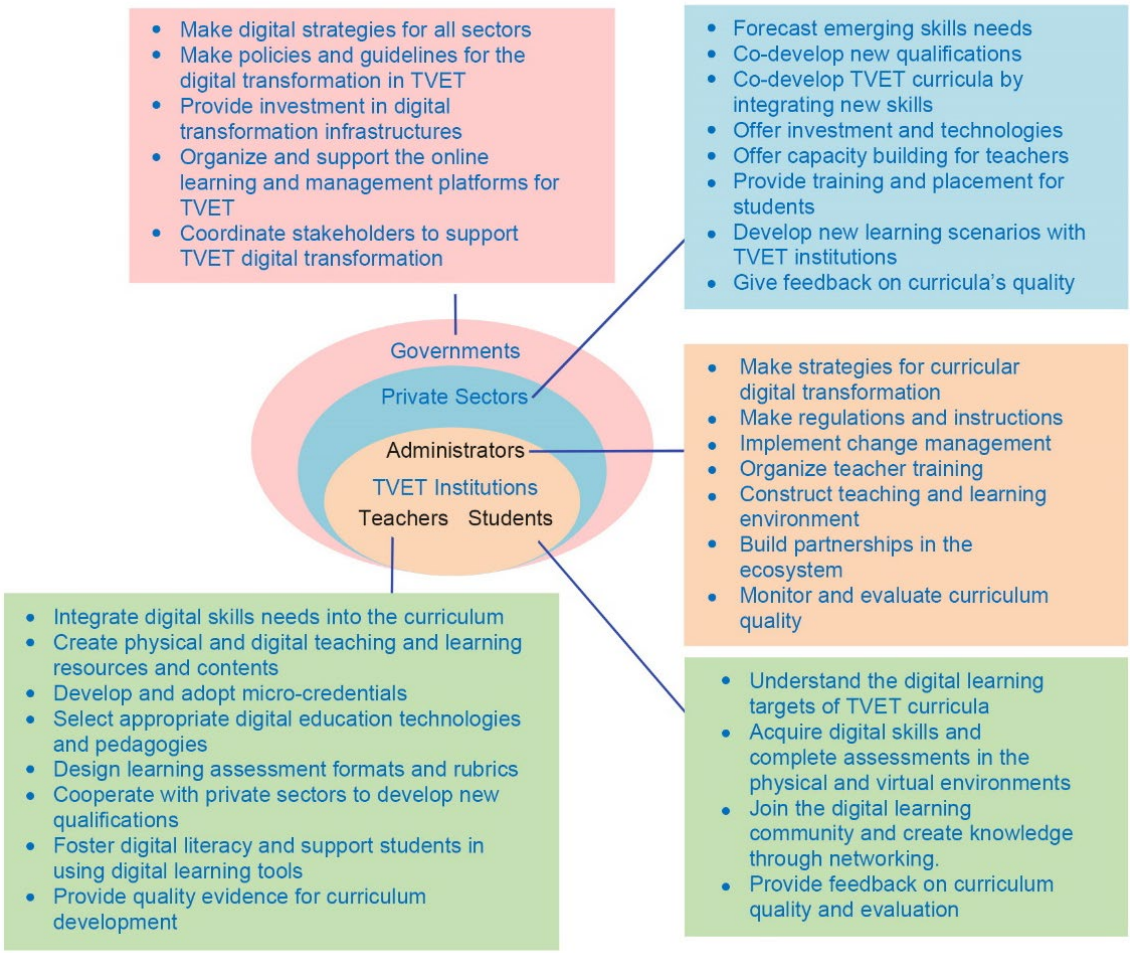
These platforms offer a range of key features. They enable teachers/trainers to create, upload, and distribute course content such as videos, audio lectures, and text documents. They also provide collaboration tools like discussion forums, instant messaging, video conferencing, and group workspaces to facilitate interaction among students and between students and teachers. These platforms enhance learner engagement through dynamic, interactive learning resources, multimedia content, interactive quizzes, and gamified elements. Importantly, they provide tools for tracking student progress, including analytics dashboards that relay information about students' participation, performance on assessments, and course completion rates. With these features, these platforms can facilitate personalized learning paths, enabling students to learn at their own pace or receive content recommendations based on their previous performance and learning styles. Lastly, these platforms extend learning beyond the classroom, allowing students to access their learning materials from anywhere and at any time, thereby providing educators and learners with flexible and innovative ways to teach and learn (Singh, 2023).

4.2 Digital transformation of TVET curricula

4.2.1 Framework for the digital transformation of TVET curricula

A curriculum is a fundamental component of a TVET programme. Curriculum design, based on the syllabus of a TVET programme, needs to consider aligning programme objectives with the demands of a digital society. Achieving this alignment depends on the collaborative efforts of various stakeholders within the TVET ecosystem. Each of these entities contributes to the digital transformation of TVET curricula, as depicted in Figure 4.2.

Figure 4.2 Framework for the digital transformation of TVET curricula



Source: Authors.

(1) Governments

Governments, encompassing national authorities, statutory bodies, and local regulatory departments, play a pivotal role in guiding and coordinating the digital transformation of TVET curricula. Their responsibilities in this transformation include:

- **Formulating digital strategies**: Governments devise digital strategies for all sectors. These strategies should be integrated into TVET curriculum development to ensure relevance in a rapidly evolving job market.
- **Establishing policies and guidelines**: Governments are tasked with formulating policies and guidelines that incentivize and support the digital transformation of TVET curricula. These policies ensure that the digital transformation aligns with national or local education goals and workforce needs.
- **Investing in digital transformation infrastructure**: The digital transformation of TVET curricula necessitates significant investment in infrastructure, such as high-speed Internet access, smart classrooms, and cloud-based platforms. Government investment is a crucial component of this infrastructure.
- **Organizing and supporting online learning platforms for TVET**: Governments organize and support the establishment of online learning and management platforms for TVET. These platforms facilitate resource integration, provide TVET courses that meet the country's digital transformation and development needs, and ensure the quality of platform construction. A successful example is the 'Smart Education of China' initiative by the National Centre for Educational Technology of China, which won the 2022 UNESCO ICT in Education Prize (UNESCO, 2023). This award recognizes the success of establishing a national public digital platform to provide access to digital learning resources.
- **Coordinating stakeholders to support TVET**: Governments can facilitate partnerships between themselves, industry, and TVET institutions to ensure that TVET curricula meet the current and future needs of the labour market.

By undertaking these actions, governments can ensure that TVET curricula are equipped to prepare a workforce skilled for the digital age.

(2) Private sectors

Private sectors, including companies, industry associations, NGOs, and private research institutions, play a crucial role in the digital transformation of TVET curricula. Their involvement spans various identification, integration, and implementation actions:

- **Forecasting emerging skills needs**: Private sectors can identify and forecast skills needs based on economic and technological trends.
- **Co-developing new qualifications**: Private sectors can collaborate with trade unions and TVET institutions to develop new qualifications that cater to future work requirements.
- **Co-developing TVET curricula by integrating new skills**: Representatives from private sectors can work with TVET institutions to develop curricula and learning resources, such as textbooks and data resources. These integrate the latest industry standards, technologies, qualifications, and digital skills essential for the modern workplace.
- **Offering investment and technologies**: Private sectors can provide investment and modern technologies to support curriculum development and implementation, ensuring alignment with the latest skills needs.
- **Offering capacity building for teachers**: The private sector can assist in upskilling TVET teachers, ensuring they understand the new qualifications and skills profiles and are adept at using and teaching new digital technologies and methodologies.
- **Providing training and placement for students**: Private sectors can offer training and placement opportunities for TVET students, enabling them to gain hands-on experience and skills.
- **Developing new learning scenarios with TVET institutions**: Private sectors can assist in designing and constructing state-of-the-art TVET learning scenarios embedded with VR, AR, and AI, among others. This ensures that TVET teachers and students align with the latest technology developments and future skills needs.
- **Providing feedback on curricula quality**: Private sectors can provide ongoing feedback to TVET institutions about the effectiveness of the curriculum and the performance of graduates in the workplace, leading to continuous improvement of the curricula.

By engaging in these actions, private sectors can ensure that TVET curricula are digitally advanced and closely aligned with the evolving needs of industries. This

enhances the employability of graduates and contributes to the overall development of a skilled and future-ready workforce. Case 3 in Appendix I—the ICT education model between Shenzhen Polytechnic University and Huawei—is a successful example of cooperation between the private sector and a TVET institution in curriculum development.

(3) Administrators of TVET institutions

Administrators of TVET institutions, including various leadership and management members, play a crucial role in steering the digital transformation of TVET curricula. Their multifaceted responsibilities include:

- **Formulating strategies for curricular digital transformation**: Administrators must devise a strategy for curricular digital transformation that aligns with the institution's mission and labour market needs. This strategy should ensure that the digital transformation aligns with national educational policies, standards, and regulations, and advocates for policies that support digital learning and teaching.
- **Establishing regulations and instructions**: Administrators should formulate institutional regulations and instructions, such as a new credit mechanism for integrating micro-credentials and instructions for mapping digital skills. These guidelines assist teachers in updating existing curricula or developing new ones that incorporate digital skills, thereby equipping students for the modern workforce.
- **Implementing change management**: Digital transformation is a systematic change. Administrators are responsible for leading this change process, which involves managing resistance, motivating staff, and cultivating a culture that embraces digital learning and innovation.
- **Organizing teacher training**: Administrators must ensure that teachers are trained to deliver digitally enriched curricula. This involves providing continuous professional development opportunities in digital pedagogy and technology use.
- **Constructing a teaching and learning environment**: Administrators must ensure that the institution has the necessary digital infrastructure to support digital tools and resources. This includes reliable Internet access, digital learning and management platforms, and digital learning materials. Moreover, they must effectively allocate resources to support digital transformation, which could involve budgeting for new technologies and digital resources.

- **Building partnerships in the ecosystem**: Administrators need to build partnerships with industry stakeholders to ensure curriculum relevance and foster opportunities for work-integrated learning, apprenticeships, and real-world digital technology applications.
- **Monitoring and evaluating curriculum quality**: Administrators should oversee the quality and efficacy of digital learning initiatives. This includes monitoring and evaluation to ensure that digital transformation efforts meet educational standards and improve learning outcomes.

By fulfilling these responsibilities, administrators act as leaders and catalysts for the digital transformation of TVET curricula. They harmonize technology with educational needs while ensuring operational efficiency, educational effectiveness, and alignment with industry trends.

(4) Teachers

Teachers are pivotal in the digital transformation of TVET curricula, with responsibilities encompassing the following activities:

- **Integrating digital skills into the curriculum**: Teachers frequently contribute to the design and periodic review of curricula, ensuring the inclusion of current digital skills and technologies pertinent to industry needs. They may collaborate with the private sector to identify emerging qualifications and skills needs, integrating digital and professional skills into the curriculum content.
- **Creating physical and digital teaching and learning resources**: The advent of digital technology has led to the emergence of various teaching and learning resources. In addition to incorporating digital teaching and learning resources into the curriculum, TVET teachers are expected to contribute to the creation of teaching and learning resources, such as videos, interactive simulation materials, and e-learning materials for virtual environments.
- **Developing and adopting micro-credentials**: Micro-credentials, a new trend in TVET in the digital age, offer flexible learning. TVET teachers should consider integrating existing micro-credentials into the curricula or developing their own micro-credential courses.
- **Selecting appropriate digital education technologies and pedagogies**: The continuous development of digital technology has popularized emerging digital

education technologies and pedagogies. To promote the digital transformation of the curriculum, teachers need to familiarize themselves with these new educational technologies and pedagogies, selecting appropriate applications for curriculum development and teaching practices.

- **Designing learning assessment formats and rubrics**: Digital transformation necessitates the development or introduction of new assessment methods capable of effectively measuring students' digital competencies. Teachers may need to utilize digital tools to track student progress and provide feedback.
- **Cooperating with the private sector to develop new qualifications**: Teachers should collaborate with industry partners to understand the digital skills employers require, ensuring the curriculum remains relevant to the job market. They are also expected to develop new qualifications with private sector experts and authorities.
- **Fostering digital literacy and supporting students in using digital learning tools**: Teachers play a role in helping students understand the importance of digital skills in the modern workforce. To ensure successful curriculum delivery, teachers need to support students in their use of digital tools and resources, guiding them in developing a responsible and ethical approach to digital technology.
- **Providing quality evidence for curriculum development**: Teachers are expected to provide evidence demonstrating that their curricula are scientifically developed and effectively delivered.

For the successful digital transformation of TVET curricula, TVET teachers require support from their institutions, including access to the necessary technology, professional development opportunities, time for collaboration and innovation, and recognition of the new challenges they face in their instructional roles.

(5) Students

Students' role in the digital transformation of curricula is to successfully acquire the target skills outlined in the curricula. Despite receiving support from all other stakeholders, students are expected to make efforts in the following areas:

- **Understanding the digital learning targets of TVET curricula**: Students should recognize that the digital learning targets of TVET curricula aim to equip

them with the digital skills necessary for success in the workforce. Understanding these targets enables students to focus on acquiring practical and relevant skills that align with industry demands, ensuring their skills are compatible with future career needs.

- **Acquiring digital skills and completing assessments in physical and virtual environments**: The digital skills students are expected to gain include the universal and specific digital skills required in the workforce, as well as the digital learning skills needed in the learning process. Students are required to complete their learning or training assessments in both physical and virtual environments.
- **Joining the digital learning community and creating knowledge through networking**: Participation in a digital learning community enables students to create and share knowledge through networking, tapping into collective intelligence that extends beyond traditional classroom boundaries. This interactive participation fosters a culture of collaborative learning, where students can benefit from diverse perspectives and expertise, acquiring digital skills as well as transversal skills.
- **Providing feedback on curriculum quality and evaluation**: Throughout the learning process, students contribute to generating learning outcomes data and provide feedback on curriculum design and implementation, which aids in improving the quality of the TVET curricula.

In summary, stakeholders play a crucial role in driving the digital transformation of curricula. Together, stakeholders collaborate to ensure that TVET curricula are responsive to the evolving digital landscape, equipping learners with the skills necessary to excel in a technologically advanced job market.

4.2.2 Approaches to the digital transformation of TVET curricula

Applying digital transformation to TVET curricula encompasses several strategies that contribute to an effective, engaging, and inclusive learning environment. Here are some notable strategies:

- **Incorporation of digital knowledge and skills**: The TVET curriculum should be updated to meet the industry's demand for digital skills. This includes fundamental skills such as digital literacy, understanding of digital tools, basics

of cloud computing, principles of cybersecurity, and specific skills like data management, coding, AI, and more, depending on the relevant vocational field.

- **Blended learning**: This strategy combines traditional classroom teaching with online learning modalities, allowing for personalized learning pace and space. It promotes active learning through discussions and practical exercises, both in class and online.
- **Use of digital learning platforms**: Technologies like Learning Management Systems (LMS) or educational apps offer an integrated platform for content delivery, interaction, progress tracking, and assignment management. They support both synchronous (real-time, scheduled) and asynchronous (self-paced) learning options.
- **Immersive learning experiences**: AR and VR technologies can simulate real-world environments for skill training, offering safe, risk-free, and highly engaging learning experiences. For instance, electricians or welders can use VR tools to practice complex tasks virtually before applying them in the real world.
- **Interactive training materials**: Digital transformation involves converting traditional teaching materials into interactive formats. These could be e-books embedded with links, audio, and visual elements, interactive videos, podcasts accessible on-the-go, or gamified quizzes. This strategy enhances learner engagement and knowledge retention.
- **Collaborative learning tools**: Digitalization facilitates collaborative learning through tools that enable real-time group work, peer assessment, and online discussions. This not only makes learning more engaging but also promotes critical thinking, problem solving, and teamwork.
- **E-portfolio**: An e-portfolio system allows learners to showcase their learning journey, work samples, achievements, and competencies in a digital format. It serves as a powerful tool for continuous self-assessment, reflection, and showcasing their skills to potential employers.
- **Digital tools for assessment and feedback**: Digital tools can provide immediate, ongoing feedback and assessment. Instead of isolated, high-stakes exams, learners receive continuous feedback on their learning progress, helping identify gaps in understanding and adjust learning strategies promptly. For example, AI

technology and tools have been used to enhance learning assessment and evaluation (Rasheed, 2023; Huang et al., 2022).

- **Short courses and micro-credentials**: Micro-credentials are gaining popularity due to their flexibility. With more than 700,000 micro-credentials offered from various sources (EDUCAUSE, 2021), they provide a more flexible and accessible way for individuals to acquire and demonstrate specific skills. Micro-credentials can be awarded to learners upon completion of a short course or through recognition of prior learning, which is an effective solution for upskilling and reskilling (Hijden & Martin, 2023).

These strategies aim to leverage digital technologies to enhance learning experiences, foster skill development, ensure curriculum relevance to industry demands, and ultimately make TVET training more impactful and effective.

4.3 Summary

The chapter delves into the digital transformation of TVET programmes and curricula, discussing the rationale, frameworks, and strategies. Notable shifts in this transformation include (1) TVET training objectives transitioning from ‘specialized’ to ‘versatile’, (2) TVET programme structure from ‘independent’ to ‘clustered’, (3) programme delivery from ‘institution-based’ to ‘ecosystem-collaborative’, (4) programme learning pathways from ‘standardized’ to ‘flexible’, and (5) programme learning/training scenarios from ‘physical’ to ‘physical-virtual blended’.

Considering these shifts, this chapter presents a flowchart that visually illustrates the process of the digital transformation of TVET programmes and curricula. Key strategies for this transformation include the formation of a digital transformation ecosystem and the establishment of digital-enabled facilities and platforms for teaching, learning, and research. These include virtual simulation training centres, virtual teaching and research centres, programme teaching and learning databanks, and online learning or e-learning platforms.

This chapter emphasizes that the successful digital transformation of TVET curricula necessitates collaborative efforts from stakeholders across the TVET ecosystem. A framework for the digital transformation of TVET curricula was developed to outline the roles and contributions of different stakeholders, including governments, private sectors, and members of TVET institutions (administrators, teachers, and students). The

strategies for the digital transformation of TVET curricula include incorporating digital knowledge and skills, promoting blended learning, utilizing digital learning platforms, fostering immersive learning experiences, using interactive training materials, collaborative learning tools, e-portfolios, digital tools for assessment and feedback, and digital certification.

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Chapter 5

Digital Transformation of EdTech and Pedagogy in TVET

Xueying Chen and Liucheng Pan

This chapter offers an overview of the latest EdTech and how digital technologies are transforming Technical and Vocational Education and Training (TVET) pedagogy. It delves into the integration of advanced technologies such as AI, extended reality technologies, and cloud computing. These technologies present a future where TVET surpasses traditional boundaries, becoming more inclusive, accessible, and in line with industry demands. The chapter highlights the challenges and opportunities in this digital era, ranging from addressing infrastructure disparities across countries to harnessing the potential of Open Educational Resources (OERs). It presents promising technology-assisted pedagogies and underscores the critical need for developing new pedagogical strategies to fully exploit the benefits of digital transformation.

5.1 Infrastructure for digital transformation in TVET

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X. Yang & W. Yang (Eds.), *Digital Transformation in Global TVET: Methodology and Practices*. UNESCO Chair on Digitalization in TVET.

5.1.1 Reducing disparities: Urgency for digital transformation in middle-to-low-income countries

Globally, the modernization and digital transformation of TVET have become focal points in national policies, reflecting a commitment to shaping the future of education. However, a significant gap exists between high-income and middle-to-low-income countries in terms of TVET infrastructure. While high-income countries benefit from advanced educational equipment, robust network infrastructure, and state-of-the-art educational technologies, middle-to-low-income countries often struggle with inadequate infrastructure, a lack of qualified teaching staff, and financial constraints. The disparities in TVET infrastructure between high-income and middle-to-low-income countries highlight the difficulties for the latter in meeting the demands of modern industries. This infrastructure gap considerably hinders the ability of middle-to-low-income countries' TVET systems to equip students with the necessary skills for the job market, leading to increased employment challenges. Recognizing the urgency of the situation, the need for digital transformation in TVET becomes particularly pressing for middle-to-low-income countries. To bridge this gap and support the effective implementation of digital education, it is crucial to establish a robust foundational base. This foundational effort is vital to ensure equitable access to quality TVET, enabling students in middle-to-low-income countries to navigate the evolving demands of the job market and contribute significantly to the global workforce.

5.1.2 Building the digital foundation: key elements in TVET infrastructure

The infrastructure development for digital transformation in TVET aims to revolutionize the traditional TVET ecosystem and teaching-learning models with the support of modern technology. This transformation seeks to create a more dynamic, efficient, and technologically advanced educational environment within TVET, fostering improved learning outcomes, increased accessibility, and alignment with contemporary industry needs. The process involves constructing various infrastructures and allocating resources, providing an optimized technological environment and systemic support to ensure the smooth implementation and effectiveness of the transformation. The following are key elements in the construction of the foundation for digital trans-formation:

(1) Hardware facilities

- **Advanced computers and tablets**

  In the field of TVET, advanced computers and tablets have become essential learning tools. These devices not only provide digital versions of educational materials but also support students in practical activities and virtual experiments, thereby enhancing the learning experience. More sophisticated hardware, such as high-performance computers, can be utilized for complex simulations and training, enabling students to better adapt to professional environments.

- **Virtual reality devices**

  Virtual reality (VR) devices are pivotal in the digital transformation of TVET hardware. VR technology allows students to immerse themselves in various occupational scenarios, thereby enhancing their practical skills. For instance, in the medical field, students can use VR to simulate surgeries, improving their practical experience and increasing precision and accuracy in their future professional training.

- **High-speed and stable network connectivity**

  High-speed and stable network connectivity is at the heart of digital education. During the digital transformation of TVET, it is crucial to ensure that TVET schools and institutions have reliable network infrastructure. This infrastructure supports real-time online teaching, video conferences, and remote training, while also providing students with broader learning opportunities. It encourages students' active participation in global educational exchanges and fosters an open learning environment. Enhancing this digital hardware foundation will further propel TVET development, equipping students to meet future professional challenges.

(2) Software support

- **Learning platforms**

  Learning platforms, designed for education, training, e-learning, or digital learning, cater to the specific learning needs of diverse user groups (UNESCO,

2023). The establishment of comprehensive online learning platforms is vital for the digital transformation of TVET. These platforms offer flexible and accessible learning opportunities for TVET students by providing access to a wide range of learning materials, including video lectures, interactive quizzes, and real-time collaborative tools. The integration of online learning platforms enhances flexibility, allowing students to engage in self-paced learning and access resources at their convenience. It also empowers learners with self-directed study options, enabling them to tailor their educational journey to individual schedules and preferences. Students benefit from a comprehensive and interactive learning experience through the diverse array of resources. The ongoing development of learning platforms emphasizes inclusivity, ensuring that TVET remains dynamic and adaptive to diverse learning styles. Moreover, these platforms facilitate the incorporation of multimedia elements, fostering a more engaging and immersive learning experience within the TVET landscape.

- **Educational management systems**

  Educational management systems (EMS) are integral components in the digital transformation of TVET infrastructure. They serve as comprehensive hubs that integrate student information, course planning, and teaching resources. Through effective data integration, these systems enable institutions to monitor student progress and teaching effectiveness, fostering a deeper understanding of student needs. The application of EMS ensures streamlined administration, efficient resource allocation, and continuous improvement in educational quality within TVET. These systems play a crucial role in the adaptive, data-driven decision-making process, contributing to personalized and effective teaching methodologies that enhance the overall educational experience.

- **Online assessment systems**

  The integration of online assessment systems is a significant stride in the digital transformation of TVET software support. These systems provide a dynamic platform for evaluating student performance, delivering prompt feedback, and assessing learning outcomes. Features such as automated grading and immediate result dissemination streamline the evaluation process, saving educators' time and

fostering a responsive learning environment. Moreover, these systems facilitate data-driven decision-making, enabling educational institutions to modify their curriculum and teaching methods based on real-time insights into student performance and understanding.

(3) Digital teaching environment

- **Multimedia classrooms**

  The digitization of TVET entails the establishment of multimedia classrooms, signifying a shift from traditional instructional spaces. This transformation involves the integration of advanced audio-visual technologies, promoting interactive and engaging learning experiences. Multimedia classrooms act as dynamic hubs, enabling the seamless integration of digital content and fostering collaborative, technology-enhanced education. In practical terms, multimedia classrooms allow educators to present a variety of learning materials digitally, including video lectures, interactive simulations, and multimedia resources. This digital shift ensures the real-time adaptability of content, maintaining its relevance to evolving curricular needs. The interactive nature of multimedia classrooms fosters an environment that encourages student participation, enhancing the overall educational experience.

- **Smart classrooms**

  Smart classrooms, characterized by the integration of cutting-edge technologies, represent a significant advancement in TVET, creating adaptive and interactive learning environments. The digital transformation involves the incorporation of electronic whiteboards, projectors, and collaborative software, redefining traditional teaching methodologies. In practice, smart classrooms enable educators to conduct interactive discussions, collaborative activities, and multimedia presentations. Electronic whiteboards and projectors serve as tools for visualizing complex concepts, contributing to improved understanding. The integration of online resources and interactive applications offers students a diverse range of educational materials, tailoring the learning experience to individual preferences. Smart classrooms play a pivotal role in preparing students for the demands of a technologically advanced workforce.

- **Virtual simulation training centres**

  The digital transformation of TVET includes the establishment of virtual simulation training centres, revolutionizing practical training through immersive experiences. These centres utilize VR or AR technologies to create lifelike scenarios, bridging the gap between theoretical knowledge and practical application. Virtual simulation training centres enhance skills and competency development. They are particularly valuable for disciplines requiring hands-on experience, such as medicine and engineering. Students engage in realistic simulations, practising procedures and tasks relevant to their future professions. This approach accelerates the transition from theory to practice, fostering a high level of competence and precision. The application of virtual simulation training centres ensures that TVET aligns with industry demands.

(4) Digital security

- The continuous improvement of the digital security framework in TVET institutions marks a significant milestone in network information security management. Besides the development of digital hardware, software facilities, and a digital teaching environment, digital support conditions are also reflected in the construction of digital security. This is a crucial prerequisite for supporting the digital development of TVET institutions.

- **Information security protection**

  Digital transformation necessitates the protection of sensitive data and privacy information, requiring measures to prevent malicious attacks and data breaches. Therefore, TVET institutions must establish a comprehensive system encompassing advanced encryption techniques, access controls, and security audits. This is paramount for safeguarding the personal information of students and educators, mitigating the risks of potential cyber threats and data leaks. A robust information security framework is essential for creating a stable and reliable digital education platform.

- **Dynamic upgrades of security measures**

As technology continuously advances, digital security undergoes dynamic development to address emerging challenges. Timely updates and ongoing training become imperative to adapt to new security threats. Digital security in digital transformation should be a dynamic and continually optimized system that can protect all participants in TVET. This adaptive approach ensures the achievement of digital transformation goals, providing students with a secure, efficient, and innovative learning environment. In conclusion, digital security is integral to the success of the digital transformation in TVET. TVET institutions can create a safe and conducive digital learning environment for all stakeholders via robust information security practices and dynamic adaptations to emerging threats.

5.2 Development and application of digital EdTech

With the increasing integration of emerging technologies in daily life and production, new teaching methodologies are being developed in the field of TVET. This evolution is transforming how education is accessed, learning methods are implemented, and assessment and certification processes are conducted. Technology-driven teaching and learning models are freeing learners worldwide from traditional constraints such as educational costs and enrolment limitations, allowing them to pursue education at their convenience, anytime, anywhere. The ILO and UNESCO assert that while digital technologies increase the demand for new skills, they also create new opportunities and challenges for TVET and skills-development systems (Grech & Camilleri, 2020). The ILO has identified five technologies driving digital innovation in TVET.

5.2.1 Ubiquitous computing

Ubiquitous computing, a cornerstone in the digital learning landscape, provides global access to information and computing power via the Internet, transcending geographical constraints. In educational contexts, especially in areas lacking educational resources, ubiquitous computing infrastructure is crucial for delivering educational opportunities. This paradigm encompasses three key technologies identified in the ILO's report (Grech & Camilleri, 2020):

- Broadband, which delivers high-speed Internet for applications such as video conferencing
- Mobile broadband, which enables wireless Internet access through technologies like 3G, 4G, and 5G, now includes innovations like low-cost global satellite Internet
- Cloud computing, which offloads tasks to remote servers, facilitating access to extensive computing power

Collectively, these technologies empower individuals to access vast information and computing resources globally, even from affordable devices like mobile phones, thereby fostering inclusive learning environments worldwide.

5.2.2 Collaboration technologies

In the domain of collaboration technologies, the complexity of joint efforts to achieve common goals has escalated in the contemporary digital era. Facilitated by network computing, the Internet, and mobile devices, collaboration has overcome physical limitations, fostering innovative work methods and organizational structures. Platforms such as Facebook, Google Groups, Dropbox, Google Drive, WhatsApp, and Skype act as catalysts for collaboration, prioritizing efficiency and project management. Slack, a notable instance, amalgamates messaging, file sharing, and video calls into a single interface, simplifying team communication. However, the transition to online collaboration necessitates new skills and unseen coordination efforts, presenting obstacles to seamless teamwork. This digital metamorphosis requires ongoing adaptation to emerging technologies and needs, highlighting the crucial role of collaboration tools in contemporary work environments.

5.2.3 Artificial intelligence

AI encompasses technologies such as deep learning, natural language processing, and signal recognition, enabling computers to learn and interact in a manner similar to humans (Grech & Camilleri, 2020). AI is becoming increasingly indispensable in the field of education, particularly in TVET, where it enhances efficiency, effectiveness, and personalization.

- **Personalized Recommendation Systems**: AI-powered systems analyze multidimensional data, including learning records, preferences, and goals, to provide tailored learning resources. These resources encompass online courses, textbooks, and tools. In the TVET sector, AI assists in recommending educational/training resources, learning opportunities, and personalized career paths.
- **Supplementary Tool for Teaching and Learning**: AI can simulate teacher roles to guide students, answer queries, and facilitate interactive learning. Intelligent Tutoring Systems (ITS) offered by AI provide real-time support. Additionally, AI-driven translation aids in the global dissemination of educational materials.
- **Assessment Tools**: AI-powered tools offer objective and efficient evaluations of students' learning outcomes, knowledge levels, and skills. AI is utilized in assessing practical skills through simulated environments and sensor technologies. It also assists in evaluating standardized tests, providing feedback on subjective questions such as writing, detecting errors, and offering suggestions to aid teachers in grading tasks.
- **Generative AI (GenAI)**: GenAI, widely regarded by many higher education experts as one of the most revolutionary technologies of our time, enables individuals to create digital content such as audio, images, text, simulations, and videos with minimal coding or programming knowledge, thanks to low-code and no-code technologies. Educators can utilize GenAI tools to draft reports and lecture materials, disseminating their work extensively to the audience. This technology aids individuals in automating mundane tasks and tackling complex problems more effectively (EDUCAUSE, 2023).

However, the rise of GenAI also raises concerns. The remarkable creativity of GenAI tools may impede learners' creative expression and personal cognitive development. This necessitates a shift in teaching evaluation methods, from assessing students' ability to memorize and reorganize information to evaluating their higher-order thinking skills. Furthermore, teachers bear the responsibility of providing students with knowledge training on the ethics and morals of AI, striving to mitigate the potential negative impacts of GenAI.

The varied applications of AI in education underscore its transformative influence on teaching and learning approaches. These instances exemplify the potential of AI to revolutionize education, particularly in TVET systems.

5.2.4 Extended reality technologies

Extended reality technologies comprise a diverse array of technologies, including VR, AR, and mixed reality (MR).

- **Virtual Reality**: VR immerses users in computer-generated environments. With specialized headsets, users can interact with objects and scenarios in simulated worlds as if they were physically present.
- **Augmented Reality**: AR enhances the real world by overlaying digital information, such as images, text, or 3D models, onto physical objects or environments. Users can interact with both the physical and digital aspects of their surroundings through smartphones, tablets, or specialized AR glasses.
- **Mixed Reality**: MR merges the virtual and real worlds, allowing users to interact with both digital and physical elements simultaneously. This technology uses advanced sensors and imaging techniques to create immersive environments where digital objects coexist and interact with real-world surroundings.

The incorporation of extended reality technology in TVET transforms traditional teaching methods by offering immersive, interactive, and engaging learning experiences. VR simulations enable students to practice hands-on skills in a virtual yet realistic environment, reducing the risks associated with physical training. AR applications provide on-the-job guidance, improving productivity and ensuring accurate task execution. MR scenarios foster collaborative learning by encouraging students to work together in shared virtual spaces, thereby enhancing teamwork and communication skills vital for the modern workforce.

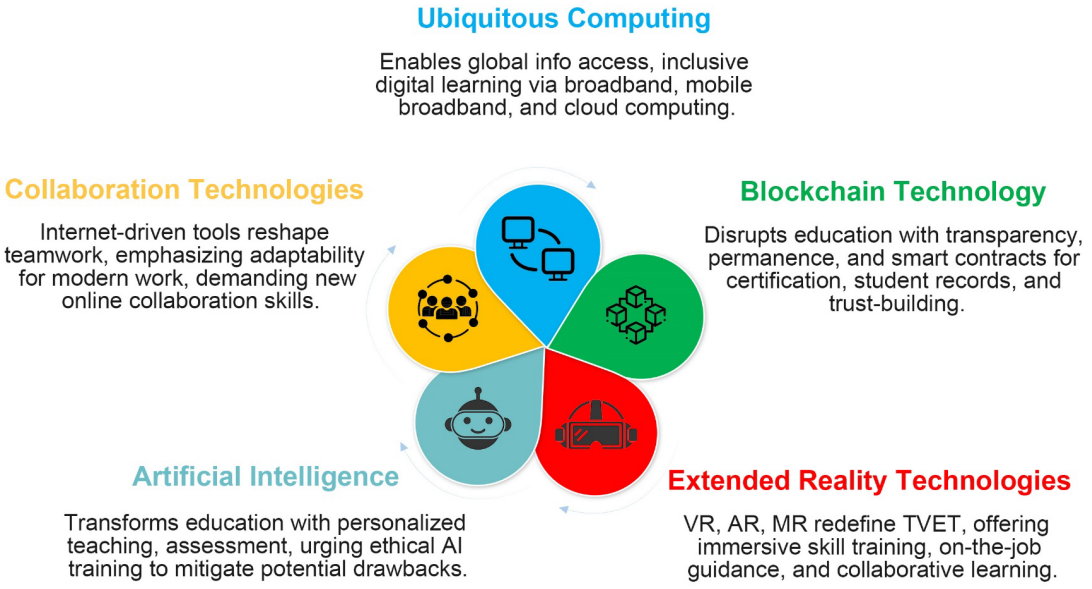
The use of extended reality technology in TVET breaks conventional boundaries, providing students with unparalleled opportunities to improve their skills, knowledge, and confidence. By harnessing the immersive capabilities of VR, the contextual guidance of AR, and the interactive nature of MR, TVET institutes can equip students for the demands of a constantly evolving professional landscape, ensuring their readiness and adaptability in the face of technological advancements.

5.2.5 Blockchain technology

Also referred to as distributed ledger technologies, blockchain technology has immense potential to disrupt traditional products and services due to its decentralized nature and unique features, such as the permanence of records and the ability to execute smart contracts. These characteristics distinguish blockchain-based solutions from previous Internet-based commercial developments and carry significant implications for the education sector. Although education is not currently a focal point for many national blockchain initiatives, the technology's potential to impact activities based on time-stamped ledgers is evident.

In education, blockchain technology could revolutionize areas such as certification, student record management, intellectual property management, payment processing, and student information systems. From a social perspective, blockchain technology offers self-sovereignty, instils trust through transparent and immutable records, eliminates the need for central controlling authorities, and fosters direct collaboration between parties involved in transactions (Grech & Camilleri, 2017). These qualities empower users, enhance security, and pave the way for innovation in the educational landscape. See Figure 5.1 for technologies driving the digital transformation.

Figure 5.1 Five technologies driving digital transformation in TVET



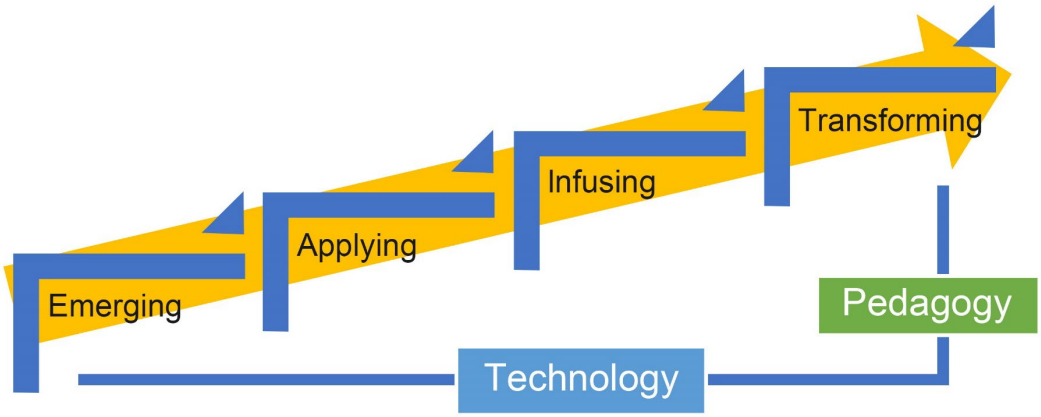
Source: Adapted from Grech and Camilleri (2020).

5.3 Adoption of digital pedagogy

5.3.1 Integrating information communication technology into pedagogy

From Figure 5.2, a four-stage model proposed by Anderson (2010) presents the adoption and use of ICT in teaching. The stages are as follows:

Figure 5.2 Four stages of ICT adoption in education



Source: Adapted from Anderson (2010).

- **Emerging**: Schools have begun to introduce computers and explore their potential for school management and classroom teaching. The focus is on acquiring basic ICT skills and identifying ICT components. Teaching remains teacher-centred and didactic.
- **Applying**: Schools have procured more ICT equipment and are modifying the curriculum to increase ICT use across various subjects. Teachers employ specific software tools, such as drawing, designing, modelling, and simulations in their instruction. Although teaching remains teacher-centred, e-learning is integrated into the curriculum rather than being a separate subject.
- **Infusing**: Schools are integrating ICT across the curriculum and utilizing a variety of multimedia tools to facilitate students' learning. Teachers select the most suitable tools for a given task and use them collectively to solve real-world problems. Teaching is learner-centred and collaborative, with ICT being incorporated into all aspects of teachers' professional lives.
- **Transforming**: Schools have fully integrated ICT into the curriculum and the organization, creating innovative learning environments that transform classroom

learning. ICT is an integral part of the daily lives of the school and the community. Teaching is collaborative and creative, with ICT facilitating students' knowledge construction and higher-order thinking.

5.3.2 Blended learning

In higher education, the adoption of distance and blended learning has been a topic of ongoing discussion and critique. While some educators have reservations, many view blended learning as a more effective alternative to traditional in-person classes. The COVID-19 pandemic necessitated the rapid global implementation of distance and blended learning, as schools adapted to online classes, leading to technological innovations and widespread adoption of blended learning due to pandemic-related school closures.

This shift in course delivery formats has blurred the boundaries between traditional face-to-face and online learning environments. In this evolving landscape, educators are compelled to embrace digital transformation in teaching philosophies, methodologies, and educational technologies. They must acquire the pedagogical knowledge and ICT skills necessary for effective cross-modal teaching.

Blended learning, which combines traditional face-to-face instruction with digital technologies, creates a flexible, personalized, and effective learning environment. This approach enables TVET institutions to offer diverse learning experiences, such as online courses, virtual laboratories, and interactive multimedia content, complementing traditional classroom teaching.

Key aspects of blended learning in TVET include:

- **Flexibility**: Blended learning allows students to access learning materials and resources at their own pace, accommodating various learning styles and needs.
- **Personalization**: Blended learning enables instructors to provide personalized learning pathways and support, using data-driven insights to identify students' strengths and weaknesses.
- **Engagement**: Blended learning uses digital technologies to create interactive and engaging learning experiences, promoting student motivation and retention.

- **Continuous feedback**: Blended learning facilitates continuous feedback through online assessments, discussion forums, and learning analytics, helping students monitor their progress and receive timely support.

5.3.3 Simulation-based learning

Other promising ICT-enhanced innovative pedagogies for TVET include simulation-based learning. Specifically, VR, AR, and other simulation technologies can model work environments digitally and have emerged as ground-breaking approaches in skill training and knowledge acquisition. VR transcends traditional learning methods by creating immersive, realistic, yet risk-free environments for trainees. In the context of TVET, the value of simulation-based learning is profound. It aligns with the sector's emphasis on practical, skill-based education and facilitates the acquisition of specific vocational skills in a controlled, replicable, and scalable manner. By providing practical experience in a virtual setting, it bridges the gap between theoretical knowledge and practical application, preparing trainees for real-world challenges. Another significant advantage of simulation-based learning is its cost-effectiveness. By eliminating expenses related to physical venue rentals, travel, consultant fees, and time away from work, it presents a more economical alternative to traditional methods. This aspect is particularly relevant in TVET, where resource optimization is crucial.

However, challenges such as high development costs, extensive time investment, technical complexity, limited accessibility, and transferability must be addressed. Collaborating with professional online learning development companies can be an effective solution for creating and maintaining high-quality simulation-based learning projects. Empirical findings from recent studies underscore the pedagogical effectiveness of simulation-based learning in TVET. Simulations offer beneficial learning experiences through the development of teamwork, engaging learning methods, and the integration of knowledge from other courses. Moreover, simulations have proven to be a useful tool for developing skills essential for various sectors.

5.3.4 Game-based learning

Game-based learning (GBL), also known as gamification, is gaining prominence in educational settings. GBL is an educational approach that employs games as teaching and

learning tools. As defined by Shaffer et al. (2005), GBL is a gameplay type with defined learning outcomes, often used in educational settings to facilitate students' understanding of processes or concepts through play.

GBL offers several advantages in educational settings. It significantly enhances learner engagement and motivation towards the subject material, thereby improving the student's learning experience. GBL fosters a collaborative atmosphere, enabling learners to enhance their social and teamwork skills. This method is instrumental in developing critical thinking and problem-solving abilities among learners. Furthermore, GBL provides opportunities for personalized learning experiences, catering to individual learner needs and preferences. It is particularly beneficial for learners with special educational needs, offering a more inclusive approach to education and catering to a diverse range of learning styles and abilities.

However, several concerns are often addressed:

- **Relevance to curriculum**: The primary challenge is ensuring that the games align with the vocational curriculum. TVET focuses on practical skills and industry-specific knowledge. Therefore, games used in this context must be carefully selected or designed to reinforce these elements, ensuring they contribute effectively to vocational competencies rather than merely serving as entertainment.
- **Costly resources**: TVET institutions often operate with budget constraints. The high cost of developing or purchasing the necessary tools and equipment for GBL can be a significant barrier. Investment in GBL resources must be justified by a clear return on investment in terms of enhanced learning outcomes and improved skill acquisition.
- **Distraction risk**: While GBL can be engaging, there is a risk that games may distract learners from the learning objectives, especially if the game elements overshadow the educational content. In TVET, where the focus is on acquiring specific skills and knowledge, it is vital that GBL is structured in a way that the gaming aspects complement rather than detract from the learning process.
- **Extended screen time**: In the TVET context, where much learning is hands-on, the increased screen time associated with GBL could be counterproductive. It is important to strike a balance between traditional, hands-on training methods and

digital learning to avoid the negative health and well-being impacts of prolonged screen exposure.

While research on GBL and gamification has been well developed from K-12 to tertiary education, this topic in TVET is not a well-researched area. A systematic literature review conducted by Dahalan et al. (2023) reveals that gamification and GBL can improve academic performance, engagement, and motivation for TVET learners. The study also suggests that more research is needed to determine the gamification strategies most suited for TVET.

5.3.5 Flipped classroom

The flipped classroom is a pedagogical model that inverts the traditional instruction sequence. In this model, students initially engage with learning materials independently, such as viewing videos or reading texts, before attending class. Class time is then dedicated to activities involving higher-order thinking, such as problem solving and critical thinking, under the guidance of their instructors.

In the context of TVET, the flipped classroom model facilitates more hands-on, experiential learning during class time, as students have already acquired foundational knowledge independently. During class time, instructors can integrate elements of innovative pedagogical approaches, such as problem-/project-based learning and WBL, to enhance student engagement and promote student-centred learning. Instructors can employ case studies, simulations, and group projects to assist students in applying the knowledge they have independently acquired.

5.3.6 Precision teaching

Precision teaching (PT), developed by Lindsley in the 1960s and based on B. F. Skinner's behavioural learning theory, was initially aimed at elementary education (Evans et al., 2021). Its objective was to monitor students' learning performances and provide data-driven decision support by designing measurement processes, thereby putting 'science in the hands of students and teachers'. Over time, PT evolved into a framework for evaluating the effectiveness of any teaching method. This evolution was facilitated by advancements in information technology, leading to precise goal setting, selection of educational content and forms, measurement of learning performance, and their precise

application. PT ensures that the teaching process is measurable and controllable, achieving differentiated instruction within the classroom.

In the era of big data, every behavioural state of students during the learning process can be converted into corresponding data records, forming the basis for analyzing learning performance. By collecting various state information generated during students' learning behaviours and forming data sources that reflect learning situations, mathematical modelling methods and big data processing techniques are used to measure, analyze, and compare these data sources. This process enables the assessment and intervention of students' learning behaviours and performance, predicting future learning trends, and customizing more effective intervention methods and improvement measures for individualized student development.

PT increasingly intersects with the concept of 'personalized learning', an approach that tailors education to individual students' needs, preferences, and learning styles. While both PT and personalized learning emphasize a data-driven, student-centric approach, utilizing ongoing assessment and adaptation to meet unique learner needs, they diverge in their foundational principles and methodologies. PT is rooted in behavioural analysis and specific measurement techniques, whereas personalized learning incorporates a broader spectrum of educational theories and practices, including consideration of student interests and preferences. Today, personalized learning has gained momentum through the integration of advanced adaptive learning technologies, such as Learning Management Systems (LMS) with adaptive features, Intelligent Tutoring Systems (ITS), and AI-Powered Personalization Engines. These technologies enable more dynamic and responsive educational experiences, tailored to each student's evolving needs and performance.

For TVET, both PT and personalized learning hold significant value, aligning with the need for educational strategies that cater to diverse learning styles and vocational skill requirements. The application of PT and personalized learning in TVET can enhance the effectiveness and efficiency of skill acquisition, thereby preparing learners more effectively for the demands of the modern workforce. It is worth noting that, with the explosive development of GenAI today, AI-driven technology is promising to bring about more innovative and fine-grained applications in PT. AI can analyze vast amounts of data on individual learners, including their learning styles, pace, and performance. This allows for the creation of customized learning pathways, ensuring that each student receives

instruction tailored to their unique needs and abilities. In addition, AI enables real-time feedback and automated assessment, which is crucial in PT's emphasis on continuous measurement.

5.4 Challenges in integrating digital pedagogies in TVET

5.4.1 Redefined approaches to instructional design

The practical orientation inherent in TVET underscores its importance. However, the design of curricula for blended learning models and other online teaching methods can pose challenges. This is because the content of practical-oriented teaching, such as virtual training materials and related educational settings, may not readily adapt to meet the need. This issue becomes particularly significant when blended learning is widely adopted in the TVET field. It is essential to emphasize that blended learning extends beyond the mere transfer of traditional classroom content to online platforms. Consequently, the digitalization of TVET necessitates a redesign and reconfiguration of educational activities to ensure quality TVET delivery.

The proliferation of online courses and the evolution of teaching paradigms, driven by online educational practices that emphasize student-centred approaches, have catalyzed ongoing advancements in learning design. The 2020 EDUCAUSE Horizon Report for Teaching and Learning underscores the pivotal role of learning design within blended learning models (Brown et al., 2020). This has led to the emergence of novel educational roles such as Learning Experience Designers (LXDs) and Learning Engineers. These emerging roles prioritize student-centred approaches, advocate for collaboration and inclusivity, and are poised to become significant driving forces behind reforms in the digital transformation of pedagogy.

5.4.2 Significant investments in infrastructure

According to the *2022 Horizon Report: Teaching and Learning Edition*, blended learning spaces significantly depend on technology and demand substantial investments in infrastructure upgrades (Pelletier et al., 2022). Limitations in the available hardware and software can hinder the achievement of the desired teaching goals. It is crucial for TVET institutions to revamp their classroom ICT infrastructure. This transformation entails upgrading multimedia and smart devices, such as interactive whiteboards, projectors, and

tablets, to create a more dynamic and interactive learning atmosphere. Moreover, enhancing network infrastructure, including wired and wireless high-speed Internet, is essential to facilitate the seamless integration of online resources and emerging technologies like the IoT. Additionally, equipping classrooms with two-way cameras and video screens allows students to actively participate in lessons, whether they are attending in person or virtually.

However, for low- and middle-income countries, investments in hardware and software can present a significant financial burden. The *Education Finance Watch 2021* by the World Bank reveals that since the outbreak of the COVID-19 pandemic, two-thirds of low- and middle-income countries have reduced their education budgets, further widening the education budget gap between low-income and high-income countries (Al-Samarrai et al., 2021). Despite the current relatively modest reduction rates, the ongoing economic impact of the pandemic could exacerbate these budget cuts.

5.4.3 Higher demands on teachers' digital skills development and pedagogical innovation

In the initial phase of the COVID-19 pandemic, teachers abruptly transitioned to blended or remote teaching environments, utilizing unfamiliar technological tools with limited preparation. As the pandemic persisted, schools formulated long-term strategies for blended learning programmes, thereby elevating the expectations for teachers' ICT competency and necessitating continuous professional development. This ensures educators are adequately equipped to provide effective blended learning experiences. The heightened focus on technology integration, coupled with a dedication to student-centred learning, highlights the significance of teacher readiness. This equips them to effectively utilize digital tools and pedagogical strategies that optimally support student success in the blended learning environment. Accreditation entities and funding organizations have initiated steps to standardize remote teaching practices and establish guidelines. Consequently, as schools invest more resources into blended teaching models, the long-term importance of teacher development needs in the context of blended learning becomes increasingly apparent.

Given the trend towards the widespread adoption of blended learning models, the efforts of higher education institutions or the government to support teacher development, allocate adequate resources for enhancing teachers' ICT competency, and provide

training in teaching methods adapted to new instructional modes become a significant challenge in the successful digital transformation of higher TVET delivery.

5.5 OER for the digital transformation of TVET

The widely accepted definition of OER stems from the *UNESCO Recommendation on Open Educational Resources* (UNESCO, 2019, p. 5):

> OER are learning, teaching and research materials in any format and medium that reside in the public domain or are under copyright that have been released under an open license, that permit no-cost access, re-use, re-purpose, adaptation and redistribution by others.

Its scope extends beyond online course materials to include textbooks, course outlines, presentations, lecture notes, assignments, tests, audio, video, and animations. OER supports equitable, inclusive, and high-quality education and ensures access to educational resources for all, including individuals with disabilities and marginalized or vulnerable groups. In formal and informal education settings, OER can cater to the diverse needs of individual learners and effectively promote gender equality. Moreover, it contributes to the promotion of innovative teaching methods. Consequently, UNESCO actively advocates for and supports its utilization, recognizing its crucial role in fostering more open and inclusive educational systems.

5.5.1 Impact of OER on digital transformation in TVET

OER has significantly influenced the digital transformation of TVET. This influence manifests in several areas:

- **Access to high-quality learning materials**: OER provides a plethora of superior educational resources, including textbooks, courses, videos, and more. The accessibility of these resources ensures that TVET institutions and learners can access the most current and pertinent content, a critical aspect of digital transformation.
- **Cost reduction**: OER materials are typically free and considerably less expensive than traditional educational resources. This economic advantage helps reduce the financial barriers to education, making TVET more accessible to a wider audience.

- **Customization and adaptation**: A fundamental feature of OER is its adaptability. OER permits TVET institutions and educators to customize and adapt learning materials to meet their specific needs and requirements. This flexibility is crucial for aligning content with the rapidly evolving demands of the digital economy.
- **Global collaboration**: OER fosters global collaboration and knowledge sharing. Being open to the public means that TVET institutions and relevant stakeholders worldwide can access these resources, promoting collaboration, the exchange of best practices, and the adoption of successful digital teaching and learning methods on a global scale.
- **Innovation in teaching and learning**: OER encourages educators to explore innovative teaching methods and technologies. It supports the integration of interactive and multimedia elements, gamified content, and other digital tools into the learning experience, ultimately enhancing learning outcomes.
- **Lifelong learning**: OER supports lifelong learning by providing resources for continuous skill development and updates. In the digital age, TVET learners and professionals must continually update their skills to remain competitive, and OER facilitates this ongoing process.
- **Scalability**: OER can be easily scaled to reach a wider audience. Digital platforms can distribute OER materials to learners regardless of their location, promoting inclusivity and equal access to education.
- **Data-driven insights**: Digital OER platforms typically offer more than just resource sharing; they include monitoring and analytical capabilities, such as those found in the 'National Smart TVET' platform launched by the Chinese Ministry of Education. These features provide data and insights into learner participation and progress. TVET institutions can use this data to evaluate the effectiveness of their professional development initiatives, enabling data-driven improvements to ensure learners meet instructional objectives.
- **Policy transformation**: The adoption of OER often necessitates policy changes. TVET institutions may need to revise policies to support the integration of OER and provide training for educators to effectively utilize OER.
- **Sustainability**: OER promotes sustainability in TVET projects by reducing dependence on printed materials, lowering costs, and decreasing environmental impact.

5.5.2 Challenges in integrating OER in TVET

The exploratory research commissioned by UNESCO-UNEVOC on the potential of OER to enhance access to quality TVET yields several insights:

- **Limited attention to TVET**: Research underscores that TVET has received relatively scant attention in the OER field. Most OER research and initiatives have centred on higher education or K-12 education, with TVET largely overlooked. This highlights the need to bolster OER development and adaptation efforts tailored to TVET's specific requirements.
- **Lack of substantial research**: The study identifies a dearth of substantial OER research in the TVET sector. Despite the extensive literature on OER's role in higher education, comprehensive research on its application and impact within TVET is lacking. This underscores the need for more research and exploration in this field.
- **Limited measurable impact**: Research indicates that OER's impact on TVET has been limited thus far. There are few successful instances of OER integration into TVET curricula and programmes, suggesting the need for more efforts to effectively incorporate OER into TVET.
- **Awareness and knowledge gap**: Surveys reveal limited awareness and knowledge among TVET practitioners and policymakers regarding OER and open licensing. This knowledge gap presents an opportunity for strengthening capacity-building and awareness-raising initiatives to promote OER's benefits and potential in TVET.
- **High expectations for OER**: Despite current challenges and limitations, the study finds that many stakeholders in the TVET sector firmly believe that OER can significantly enhance the knowledge and skills of training personnel. Many stakeholders hope to see an increase in OER resources applied to TVET to promote accessibility, equity, higher quality, and efficiency.

Additional challenges in integrating OER in TVET include diverse standards across different sectors and countries, limited Internet access, rapid knowledge obsolescence in TVET, and language barriers (Schuwer & Janssen, 2017).

5.5.3 Strategy for OER development in TVET

It is crucial to underscore teachers' pivotal role. Educators, as the frontline users of OERs, must be equipped with the necessary skills. This refers to capacity-building opportunities, extending beyond ICT competency to encompass raising awareness, helping educators better understand, and effectively utilizing OER.

OER development demands systemic change rather than being a collection of isolated interventions or projects. This change should encompass policy adjustments at various institutional levels, the formulation of teacher training programmes for OER application and development, and even organizational restructuring.

Collaboration among multiple educational institutions can induce alliances, pooling resources to achieve common OER platforms. Government-led initiatives for standardization, models, frameworks, and guidelines are essential. Additionally, assessing and ensuring the quality of digital content is challenging but vital. Establishing mechanisms for quality assurance and diverse regulatory tools in the TVET-OER sphere is necessary to support sustainable and high-quality integration.

Lastly, the creation of national or international OER platforms is crucial, followed by the establishment of 'OER-TVET Champions'. These champions serve as exemplars, motivating, guiding, and aiding other educators in the development of their ICT teaching capabilities for OER applications.

5.6 Summary

This chapter underscores the importance of fostering technological innovation in TVET through digital infrastructure. The digital transformation of TVET involves the integration of modern hardware such as computers, tablets, and VR devices to support learning and practical experiences. High-speed network connectivity is essential, and software support enhances flexibility. The creation of a digital teaching environment, including multimedia classrooms, smart classrooms, and simulation training centres, promotes an immersive atmosphere. The development of robust digital security, encompassing information security protection and dynamic security measures, is crucial. Collectively, these elements form the foundation for the digitalization of TVET, ensuring equitable access to quality TVET.

The evolution of TVET is inextricably linked with emerging technologies, providing unparalleled opportunities for innovative teaching methodologies. Ubiquitous computing enables global access, collaboration technologies facilitate teamwork, AI customizes learning resources, and extended reality technologies offer immersive experiences. Blockchain technology enhances trust and collaboration. The key is to harness these advancements to create an inclusive, accessible, and adaptive learning ecosystem, freeing learners from traditional constraints.

The adoption of digital pedagogy is fundamental to the transformation of TVET. This transformation involves blended learning, which merges traditional and online environments for adaptability and engagement. Innovative modalities such as VR, AR, GBL, and the flipped classroom enhance learning experiences. Overcoming challenges in instructional design and infrastructure is crucial. This shift involves more than merely transposing content to digital platforms; it necessitates a restructuring of educational practices for a resilient and efficient TVET system within the digital ecosystem.

OER play a pivotal role in TVET's digital transformation by offering cost-free access, customization, and global collaboration. OER impacts digital transformation by enhancing accessibility, reducing costs, fostering innovation, and supporting lifelong learning. Challenges include limited attention, inadequate research, and awareness gaps. Strategies focus on empowering educators, fostering systemic transformation, and creating national and international OER platforms. Overcoming these challenges promises an inclusive, accessible, and high-quality digital transformation in TVET.

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Chapter 6

Capacity Building for Digital Transformation in TVET

Zhuoya Zhong

This chapter addresses the capacity development of three primary Technical and Vocational Education and Training (TVET) stakeholder groups: leaders, teachers, and students, in the context of digital transformation. It commences with an exploration of the concept of digital transformation leadership, detailing the eight roles of digital leaders. This is followed by an introduction to two frameworks employed for TVET leadership development, initiated by UNESCO-UNEVOC and the UNESCO Chair on Digitalization in TVET. The chapter then delves into the expected capacities of TVET teachers in terms of what to teach, how to teach, and lifelong learning in the digital age. It also introduces widely accepted digital competency frameworks for teachers globally. Furthermore, the chapter examines the anticipated digital competencies of TVET students and provides a detailed explanation of prevalent digital competence frameworks for individuals. Each section underscores distinct approaches to capacity development for various TVET stakeholder groups.

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X. Yang & W. Yang (Eds.), *Digital Transformation in Global TVET: Methodology and Practices*. UNESCO Chair on Digitalization in TVET.

6.1 TVET leadership building for digital transformation

6.1.1 Expected leadership for digital transformation

(1) Definitions of digital transformation leadership

Digital transformation leadership is recognized as the fundamental catalyst for envisioning and initiating the transformation process (Westerman et al., 2011; Hemerling et al., 2018). The significant role of digital transformation leadership, also referred to as digital leadership, can be inferred from its conceptualization from diverse perspectives. For instance, Mihardjo and Sasmoko (2019), focusing on digital technology and digitalization, defined digital transformation leadership as a leader's cultural understanding and competence in utilizing digital technology to create organizational value. Similarly, De Waal et al. (2016) perceived it as the achievement of a goal through the guidance of human assistants and the use of information and communications technology (ICT). From a business behaviour perspective, El Sawy et al. (2016) defined digital leadership as undertaking the right actions for the strategic success of digitalization within the business ecosystem. Based on a synthesis of the literature, Magesa and Jonathan (2022) provided a concise and general definition of digital leadership as 'a leader's competence to initiate, manage, and enable the digital transformation process'.

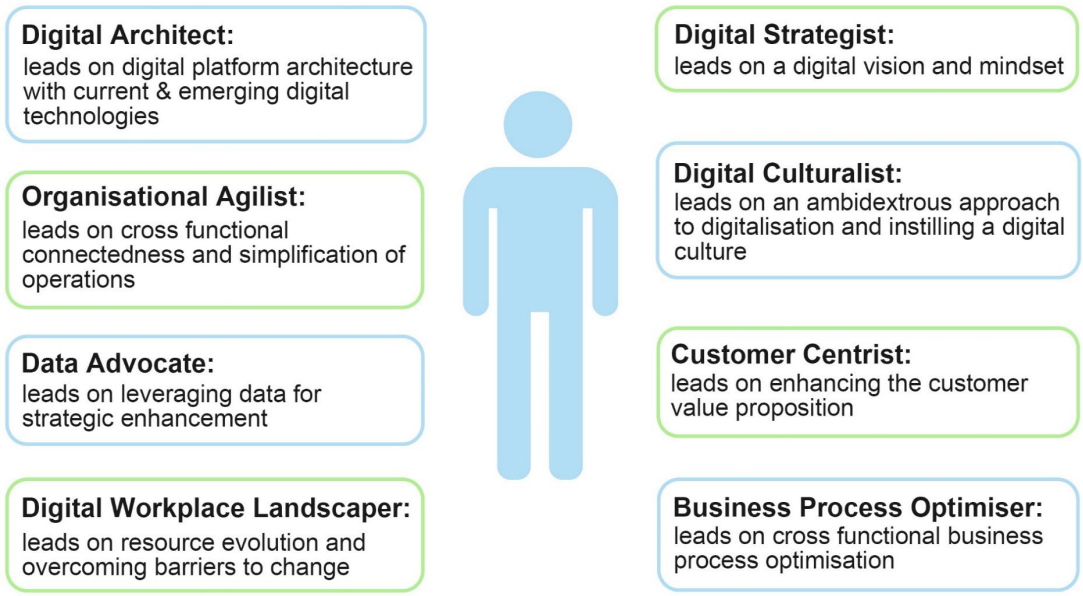
(2) Roles of a digital transformation leader

To further elucidate the concept of digital transformation leadership, we adopt the elaboration of Magesa and Jonathan (2022) on the eight roles of a digital transformation leader (Figure 6.1). Specifically, a digital transformation leader is as follows:

- A **Digital Strategist**, who strategically prioritizes digital transformation, advises senior management on digital transformation, advocates a digital vision, alters the organizational mindset, and identifies solutions to digital transformation;
- A **Digital Culturalist**, who fosters and nurtures a robust interest in digital transformation, adopts a versatile approach to encourage a digital organizational culture, and enhances the skills and competence of the employees;
- A **Digital Architect**, who designs and constructs a digital services platform, embraces a digital mindset, drives innovation in digitally enabled operations, and

actively explores and leverages digital technologies to achieve operational excellence;

Figure 6.1 Eight roles of a digital transformation leader



Source: Magesa and Jonathan (2022).

- A **Customer Centrist**, who enhances customer engagement and cooperation, cultivates a comprehensive customer experience, enhances business services, streamlines and provides digital services to customers, and generates value for them;
- An **Organizational Agilist**, who embraces beneficial organizational changes, develops the competences to exploit and explore resources for digital transformation, and recruits skilled individuals to execute digital transformation initiatives;
- A **Data Advocate**, who develops a culture and mindset centred around data, establishes a strategy for utilizing data effectively, and devises a digital technology-based architecture for managing data;
- A **Business Process Optimizer**, who revamps and optimizes business processes and ensures the changes in processes align with the business goal;
- A **Digital Workplace Landscaper**, who establishes and manages the implementation of a digital workplace, focusing on enhancing employee experience through the introduction of cutting-edge digital solutions.

Significantly, in the educational context, business processes should be interpreted as educational processes, employees should be considered faculty and staff, and customers should be viewed as students.

6.1.2 Frameworks of digital transformation leadership building in TVET

In the field of TVET, digital transformation leadership is crucial for TVET systems and institutions to initiate and implement transformation processes to remain connected to the digital world (ILO, 2020). However, there is no widely acknowledged, research-based framework of digital transformation leadership for guiding TVET leadership development. UNESCO-UNEVOC, UNESCO's designated centre for TVET, and the UNESCO Chair on Digitalization in TVET at Shenzhen Polytechnic University, China, the only establishment dedicated to digital transformation in TVET among over 900 UNESCO Chairs, have developed their TVET leadership frameworks for their TVET initiatives. These could provide guidance on leadership development for TVET transformation, as introduced below.

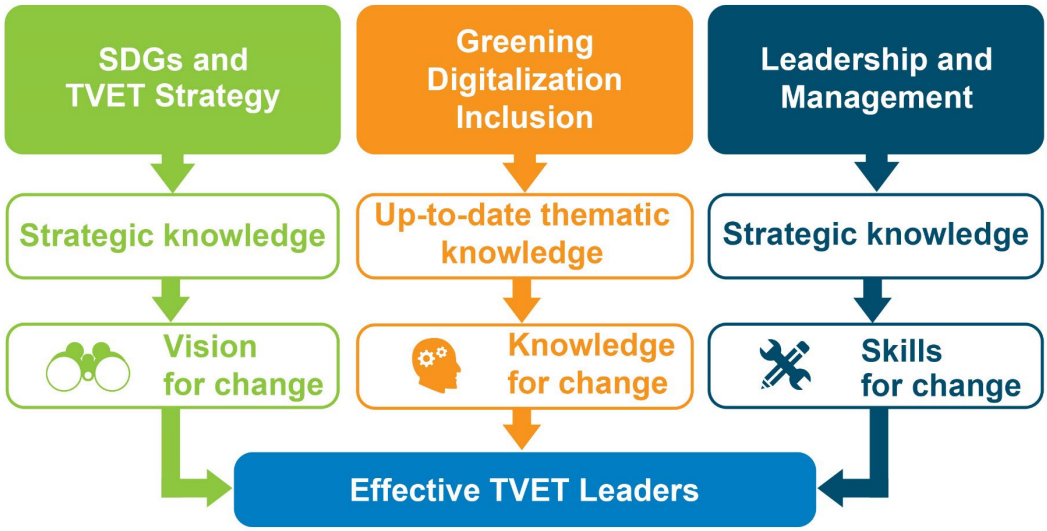
(1) TVET Leadership Programme by UNESCO-UNEVOC

While the 'UNEVOC TVET Leadership Programme Framework' is not dedicated to building digital transformation leadership, it is comprehensive and could be applied to other leadership development. The framework is based on the 'theory of change' by UNEVOC, which posits that effective leaders should possess the necessary vision, knowledge, and skills for change. Figure 6.2 shows the latest programme design (UNEVOC, 2023a):

- **Module 1 'Vision for change'** focuses on UNESCO's vision for TVET, as outlined in the UNESCO Strategy for TVET (2022–2029). It also covers global strategies for Sustainable Development Goals (SDGs) and educational transformation.
- **Module 2 'Knowledge for change'** provides thematic knowledge on greening TVET, digital transformation, and inclusive TVET. It equips leaders with the latest trends and skills needed for sustainability and inclusivity.

- **Module 3 'Skills for change'** focuses on leadership and management skills, including strategic planning and results-based management, to ensure effective TVET institutions.
- **Module 4 'Proposals and action plan for change'** guides participants to develop action plans per the knowledge gained, fostering peer learning and knowledge exchange.

Figure 6.2 UNEVOC framework of effective TVET leaders



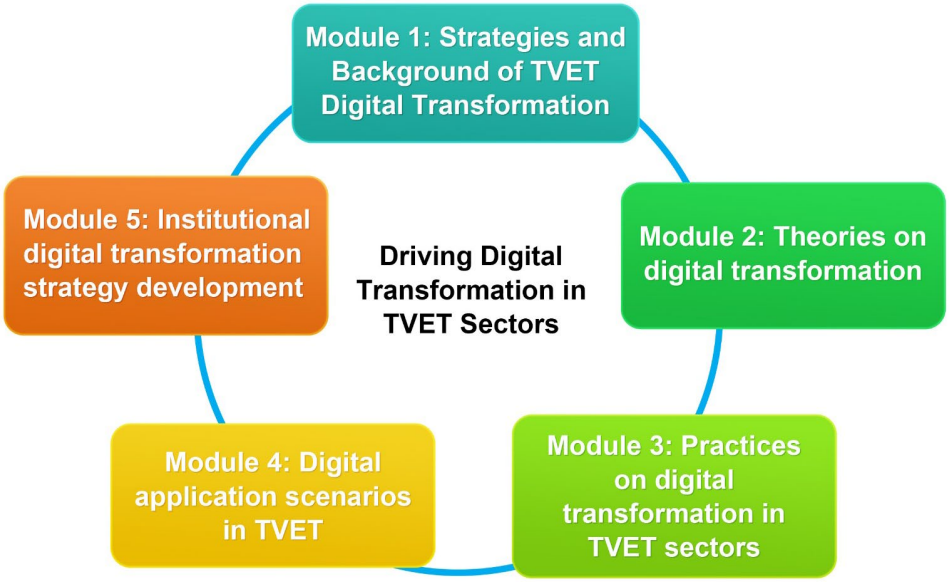
Source: UNEVOC (2023a).

Though not a specific TVET digital transformation leadership framework, all four modules address digital transformation, as digitalization is one of the three key thematic areas in this TVET initiative. The UNEVOC TVET Leadership Programme, based on this framework, has trained over 700 TVET leaders, senior management, and practitioners from more than 95 countries since 2016 (UNEVOC, 2023a). Specifically, the 2021 UNEVOC TVET Leadership Programme focused on the theme 'Skills for the Digital Transformation: How TVET Institutions Can Respond to Future Demands', supporting 31 TVET leaders and managers from 25 countries and 16 UNEVOC Centres to become effective agents of change (UNEVOC, 2021).

(2) TVET Leadership Workshop by the UNESCO Chair on Digitalization in TVET

The UNESCO Chair on Digitalization in TVET at Shenzhen Polytechnic University, China, is dedicated to fostering TVET leadership for digital changes. This commitment is manifested in an annual workshop, initiated in 2023, which targets mid-to-senior-level TVET leaders, managers, education/training programme directors from higher TVET institutions or universities of applied sciences, and policymakers from national or regional TVET authorities. The 2023 TVET Leadership Workshop saw the participation of 26 TVET leaders from 17 countries, providing a platform for the exchange of valuable insights and experiences.

Figure 6.3 Framework of TVET leadership building for digital transformation by the UNESCO Chair on Digitalization in TVET



Source: Author.

The framework of the 2023 TVET Leadership Workshop on Digital Transformation, as depicted in Figure 6.3, is detailed as follows:

- **Module 1, 'Strategies and Background of TVET Digital Transformation'**, enables participants to reflect on the strategies, backgrounds, and trends of TVET digital transformation, thereby identifying challenges and opportunities for their institutions.

- **Module 2, 'Theories on Digital Transformation'**, acquaints participants with the theories of digital transformation, encompassing the definition and framework of digital transformation in both the TVET and private sectors.
- **Module 3, 'Practices on Digital Transformation in TVET Sectors'**, is designed to enhance participants' skills through peer learning and best practices. It covers topics such as developing digital programmes and courses, transforming traditional programmes, and collaborating with private sectors.
- **Module 4, 'Digital Application Scenarios in TVET'**, offers participants the opportunity to experience digital training scenarios, such as VR/AR simulation centres and smart classrooms.
- **Module 5, 'Institutional Digital Transformation Strategy Development'**, aids participants in drafting proposals based on the knowledge acquired in the preceding modules.

This framework is aimed at supporting TVET leaders by altering their mindset, expanding their vision, fortifying their methodologies and approaches, and equipping them with practical skills for developing digital transformation strategies, thereby cultivating them into stronger digital transformation leaders.

6.1.3 Approaches to TVET digital transformation leadership building

Digital transformation in TVET is a journey of innovation that encompasses multiple dimensions, including strategy and management, teaching and learning, institutional products and services, and ecosystem partnerships (UNEVOC, 2020a). Consequently, TVET leaders must be equipped with the necessary strategies, policies, and resources to facilitate digital transformation across the institution. Reflecting on the concept of digital transformation and initiatives for building TVET leadership, several key dimensions emerge:

- **Vision building for digital transformation**: TVET leaders must envision the future of TVET in the digital era and articulate this vision to stakeholders, including management, faculty, staff, students, and social partners, thereby fostering shared inspiration.
- **Knowledge and skills development on digital transformation**: TVET leaders must acquire knowledge and skills on digital technologies and TVET processes, including management, teaching and learning, and research and development, to

navigate the complexities of integrating digital technologies into institutional governance and management.

- **Strategic planning advocacy for digital transformation**: TVET leaders are expected to develop a comprehensive strategic plan outlining approaches to successful digital transformation. This plan should consider emerging technologies and industrial trends, as TVET aims to provide technical and vocational skills for industries. Ramadan and Chen (2019) recommended that leaders engage with policymakers to advocate for policies promoting digital integration in TVET and addressing any legal or regulatory barriers.
- **Whole-institutional digital transformation implementation advocacy**: TVET leaders should mobilize all human, hardware, and software resources to systematically implement digital transformation across the institution. This includes building digital transformation competencies among management, faculty, and staff, guiding digital transformation in programme and curriculum development, and investing in digital infrastructures and platforms.
- **Ecosystems and partnerships advocacy**: TVET leaders should foster collaboration and partnerships with peer TVET institutions, higher education institutions, government agencies, and the private sector. These partnerships can form a digital transformation ecosystem and provide best practices, valuable insights, resources, and support for the transformation process.
- **Sustainability of digital transformation advocacy**: TVET leaders should establish a sustainable mechanism for digital transformation, which includes sustainable funding, a monitoring and evaluation mechanism for whole-institutional digital transformation (covering all dimensions in the strategic plan, such as programme and curriculum development, training environments and infrastructures, institutional management), and continuous professional development for management, faculty, staff, and leaders themselves.

6.2 TVET teacher capacity building for digital transformation

6.2.1 Expected TVET teacher capabilities for digital transformation

(1) Expected capacities of TVET teachers for transforming what to teach

The successful implementation of digital transformation in TVET largely hinges on the digital transformation capacities of TVET teachers. Han et al. (2023) argue that TVET teachers, being more than average digital citizens, should possess digital transformation capacities to support teaching and learning, in addition to basic digital literacy for survival in the digital age. Teachers are expected to be capable of adapting their TVET teaching towards the digital world. The ILO (2020) emphasized that teachers must identify and introduce relevant digital skills for current and future scenarios, as digitalization has extensively altered the skills required for work and life. The rationale is that up to 26 job clusters would transition towards eight job clusters powered by digitalization, covering areas such as cloud computing, big data, and AI (World Economic Forum, 2020). This leads to changes in skills needs and subsequently, changes in training contents. Han et al. (2023) echoed a similar point, stating that TVET teachers should acquire 'Technological Content Knowledge' to effectively select which technologies to teach when designing the curriculum.

(2) Expected capacities of TVET teachers for transforming how to teach

Further, teachers are expected to transform 'how to teach' in TVET. Han et al. (2023) suggest that TVET teachers need to acquire 'Technological Pedagogical Knowledge' to employ technologies pedagogically to support flexible, interactive, and inclusive teaching and learning. Specifically, the UNEVOC Centre (2022) highlights that teachers require capacity building in two aspects regarding how to teach, namely, 'the use of digital tools and services for teaching TVET' and 'the digital delivery of TVET through distance learning'. The first aspect involves integrating digital tools and technology into TVET instruction, such as utilizing AR technology to create virtual 3D models. This allows learners to interact with advanced tools and equipment used in the workplace and provides a controlled environment for practising complex tasks. The second aspect focuses on delivering TVET remotely by utilizing digital tools. This includes using videoconferencing tools like Zoom for student communication and online platforms like Moodle to share learning materials and monitor learning progress.

(3) Expected capacities of TVET teachers for lifelong learning

Lifelong learning capacities are also a crucial part of TVET teachers' expected capacities. Firstly, TVET teachers are expected to keep pace with the changes in industries and skills needs, as the digital transformation in industries brings about increasing ambiguity, uncertainty, and changes (Han et al., 2023). Specifically, some traditional industries, such as manual manufacturing and processing, might be replaced by new industries. Consequently, TVET teachers need to continually update the curricula to match the latest skills needs. Secondly, the development of technologies also drives teachers to continually improve their digital pedagogical capacities by learning new pedagogical theories and technological knowledge (Diep & Hartmann, 2016). For instance, they need to familiarize themselves with the latest training facilities and learning platforms that use emerging digital technologies, and then design how to effectively utilize these in skills delivery. Thirdly, TVET teachers should also have the capacity to shape students as lifelong learners. Exposing students to multiple learning forms, including formal, informal, in-class and out-of-class learning, and online and blended learning, might be an effective way for TVET teachers to enable students' lifelong learning.

6.2.2 Digital competence framework for teachers

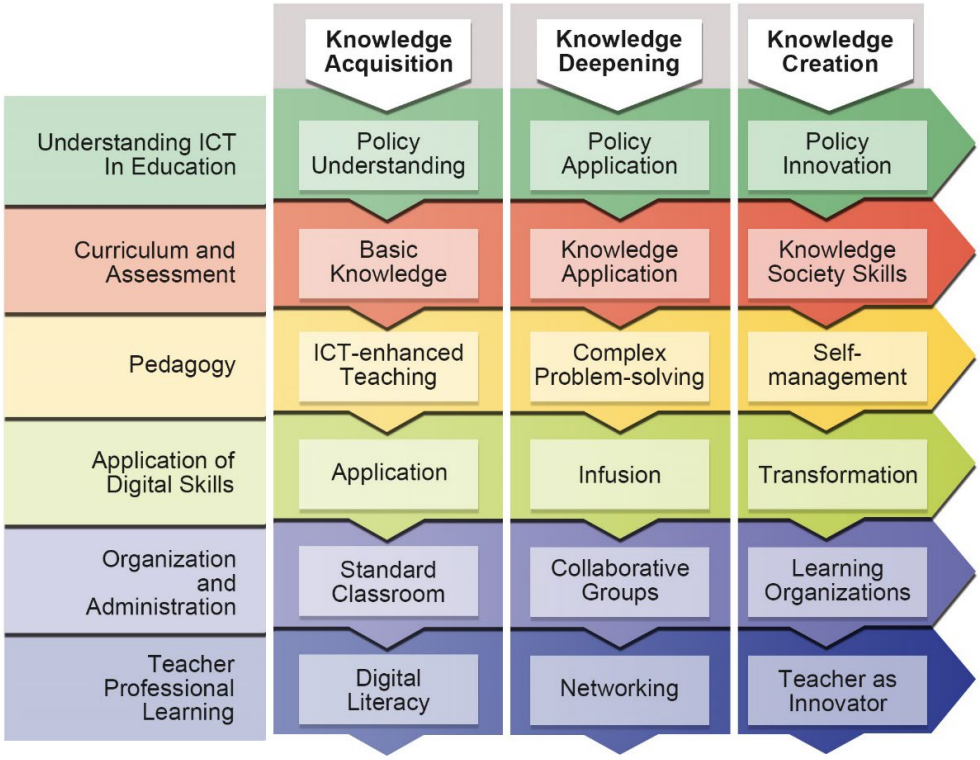
While acknowledging the importance of digital transformation capacities for TVET teachers, there is currently no dedicated digital competence framework for TVET teacher capacity building. However, several entities, including UNESCO, the European Union (EU), national governments, and various educational institutions, have developed digital literacy or skills frameworks for teachers in general, which could offer insights for TVET teacher capacity building. The following are mainstream global frameworks of teacher digital competence:

(1) UNESCO ICT Competency Framework for Teachers

The 'UNESCO ICT Competency Framework for Teachers' (ICT-CFT)' (see Figure 6.4) is a resource that assists countries in developing comprehensive policies and standards for enhancing teachers' ICT competency. It guides teacher training on the use of ICTs in education and advocates for the integration of digital skills into teachers' professional development. The latest version (Version 3) from 2018, developed in collaboration with the International Society for Technology in Education (ISTE), CISCO, Intel, and

Microsoft, emphasizes the principles of Knowledge Societies, Universal Design for Learning, and Inclusive Education. The framework comprises six competence areas: understanding ICT in education policy, curriculum and assessment, pedagogy, application of digital skills, organization and administration, and teacher professional learning. Each area is described at three levels, reflecting the progression from using technology as a supplement to transforming teaching and learning through innovative strategies. The framework, used globally and available in multiple languages (e.g. English, French, Arabic, Chinese, Russian, Spanish, Khmer, Kyrgyz, and Tajik), targets teachers, trainers, policymakers, researchers, and curriculum developers (UNESCO, 2018).

Figure 6.4 UNESCO ICT Competency Framework for Teachers (ICT-CFT) Version 3



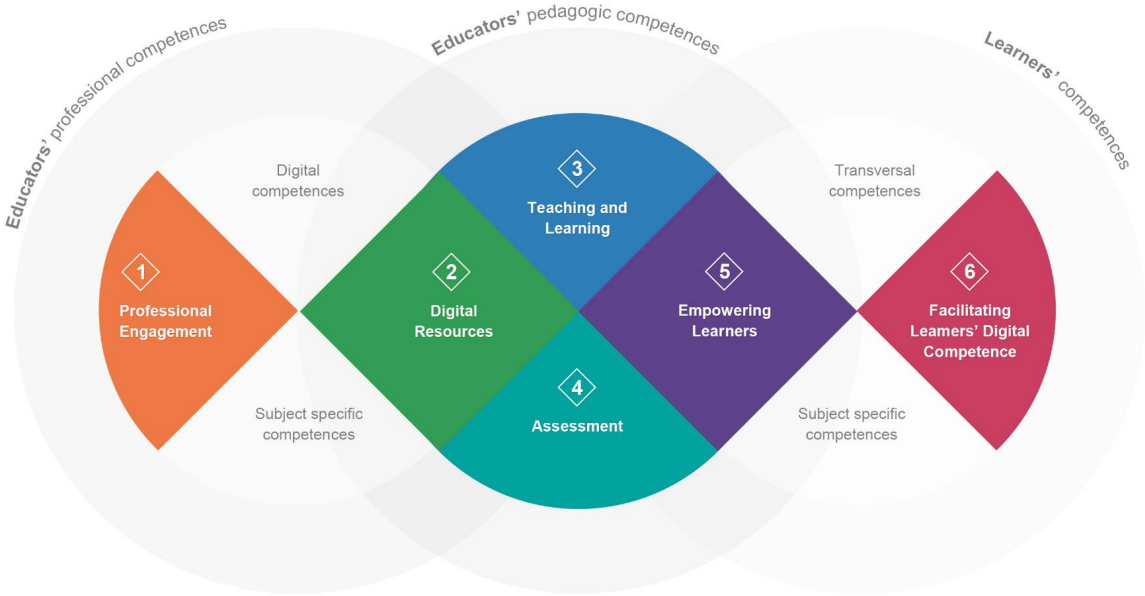
Source: UNESCO (2018).

(2) European Framework for the Digital Competence of Educators (DigCompEdu)

'DigCompEdu' is a framework developed by the EU in 2017 to help teachers and education stakeholders enhance their digital competence across all levels of education (see Figure 6.5). Created in consultation with educators from across Europe, it serves as

a common European reference framework. It lists six areas of competence, further divided into 22 competencies. These areas include professional engagement, digital resources, teaching and learning, assessment, learner empowerment, and pedagogic competencies. Each area has a six-stage progression model based on Bloom's taxonomy, allowing educators to gauge their level of competence and track their progress. The framework emphasizes the importance of supporting teachers in a comprehensive framework that can be used by member states, regional governments, educational organizations, and training providers to develop digital competence models for educators (Redecker, 2017).

Figure 6.5 European Framework for the Digital Competence of Educators (DigCompEdu)



Source: Redecke (2017).

(3) Other digital competency frameworks for teachers

Other regional, national, or individual organizations have also developed frameworks for TVET capacity building for digital transformation. These include China's 'Digital Literacy of Teachers' (Ministry of Education of China, 2022), the United States' 'Teacher Educator Technology Competencies' (Foulger et al., 2017), Norway's 'Professional Digital Competence Framework for Teachers' (Kelentrić et al., 2017), and Spain's 'Common Digital Competence Framework for Teachers' (INTEF, 2017). Each of these

frameworks serves as a guide to help teachers define the necessary digital competencies to effectively transform their teaching practices.

6.2.3 Approaches to TVET teacher capacity building for digital transformation

TVET teachers, being the key practitioners of TVET digital transformation, necessitate a comprehensive and continuous approach to capacity-building. This approach prepares them adequately to transform TVET teaching practices. It is crucial to consider the general (specific) digital competences required for (TVET) teachers. The key dimensions of TVET teacher capacity building for digital transformation include:

- **Overcoming resistance to change**: Some TVET teachers may resist adopting new technologies and digital tools due to fear of change. The primary step in capacity building is to enhance their understanding of the necessity and benefits of digital transformation, thereby inspiring them to adapt their teaching practices.
- **Developing generic digital competence**: TVET teachers need to acquire skills and knowledge on emerging digital technologies and their applications, enabling them to build students' digital competences effectively (UNEVOC, 2020b).
- **Building professional digital competence**: Besides generic digital competence, teachers need to master subject-specific knowledge and skills for digital transformation in the corresponding industry (Wuttke et al., 2020). For instance, the 'TVET Programme Director Training Workshop 2023' conducted by Shenzhen Polytechnic University introduced the latest developments of industrial chains to programme directors and guided teachers on building professional digital competence to match the digital transformation of various industries.
- **Developing pedagogical skills and expertise**: TVET teachers should be capable of using emerging instructional approaches, teaching and learning tools, and educational technologies and resources (Wuttke et al., 2020; Han et al., 2023).
- **Building digital competence for tutoring practical training**: Unlike general education, practical training is a vital part of TVET teaching and learning. It might involve using AR, VR, or extended reality (XR) training facilities and virtual training platforms. Therefore, TVET teachers, as training tutors, need to build related digital competences, such as skills in using simulation training tools and even skills in designing virtual training software (Han et al., 2023).

- **Building competence to handle different modes of learning**: TVET teachers should be competent in using digital tools, technologies, and resources to deliver online, offline, and blended learning in a flexible, interactive, inclusive, and student-centred manner (Hodges et al., 2020). This includes asynchronous distance learning in technology-mediated environments (Barbour, 2012).
- **Pursuing continuous professional development**: Given the rapid advancements in technology, teachers, as lifelong learners, should stay informed about emerging trends and best practices (Ertmer et al., 2012).

6.3 TVET student competence development for digital transformation

6.3.1 Expected TVET student competences for digital transformation

(1) Expected digital competence of TVET students as digital citizens

The rapidly evolving digital landscape has significantly increased the demand for digital transition competences among TVET students as individuals, or in other words, as digital citizens (UNESCO, 2022). In daily life, it is crucial for students to possess digital literacy to communicate, collaborate, and solve problems, such as using digital platforms and utilizing online resources. Specifically, TVET students are also required to be competent to learn in digitally transformative environments, such as in training facilitated by VR, flipped classrooms, and blended learning.

(2) Expected digital competence of TVET students as future labour

Most importantly, students, especially TVET students oriented to technical jobs, must acquire the skills necessary to navigate and utilize digital tools effectively in preparation for the future world of work. This is due to the increasing reliance of industries and their future labour force on automation, AI, and data analytics. As highlighted in the 2022 OECD report, there has been a significant increase in digital occupations in EU countries, even amidst the COVID-19 pandemic. Moreover, 'traditional' jobs, such as advertising sales, are evolving into digital marketing (OECD, 2022). Consequently, proficiency in digital technologies, including programming, data analysis, and digital marketing, enhances the employability prospects of TVET students across nearly all careers.

Employers are increasingly seeking individuals capable of leveraging technology to drive innovation and efficiency.

6.3.2 Digital competence frameworks for individuals

Despite the growing recognition of the importance of developing digital competences among TVET students, there is currently no specific competence framework for this purpose. However, international, regional, and national education stakeholders, particularly inter-governmental organizations and state governments, are actively engaged in creating digital literacy or skills frameworks for individuals. These frameworks are also relevant to TVET and could be used by TVET providers to identify the necessary digital competences for individuals, including students. Key digital competency frameworks are introduced below.

(1) Digital Literacy Global Framework

The 'Digital Literacy Global Framework (DLGF)', developed by the UNESCO Institute of Statistics, measures the SDG 4 indicator 4.4.2, which focuses on the percentage of youth and adults who have achieved a minimum level of proficiency in digital literacy skills. The DLGF builds upon the European Commission's 'Digital Competence Framework for Citizens (DigComp 2.0)' and incorporates input from experts and digital literacy frameworks in 47 countries. It comprises seven digital competence areas, as shown in Table 6.1. The DLGF targets policymakers, researchers, and teachers/trainers and serves as a global framework for measuring digital literacy skills, aiming to promote digital inclusion and development worldwide (UNESCO Institute of Statistics, 2018).

Table 6.1 Proposed competence areas in the Digital Literacy Global Framework

Competence Area	Descriptions
0. Devices and software operations	To identify and use hardware tools and technologies. To identify data, information and digital content needed to operate software tools and technologies.
1. Information and data literacy	To articulate information needs, to locate and retrieve digital data, information and content. To judge the relevance of the source and its content. To store, manage and organize digital data, information and content.

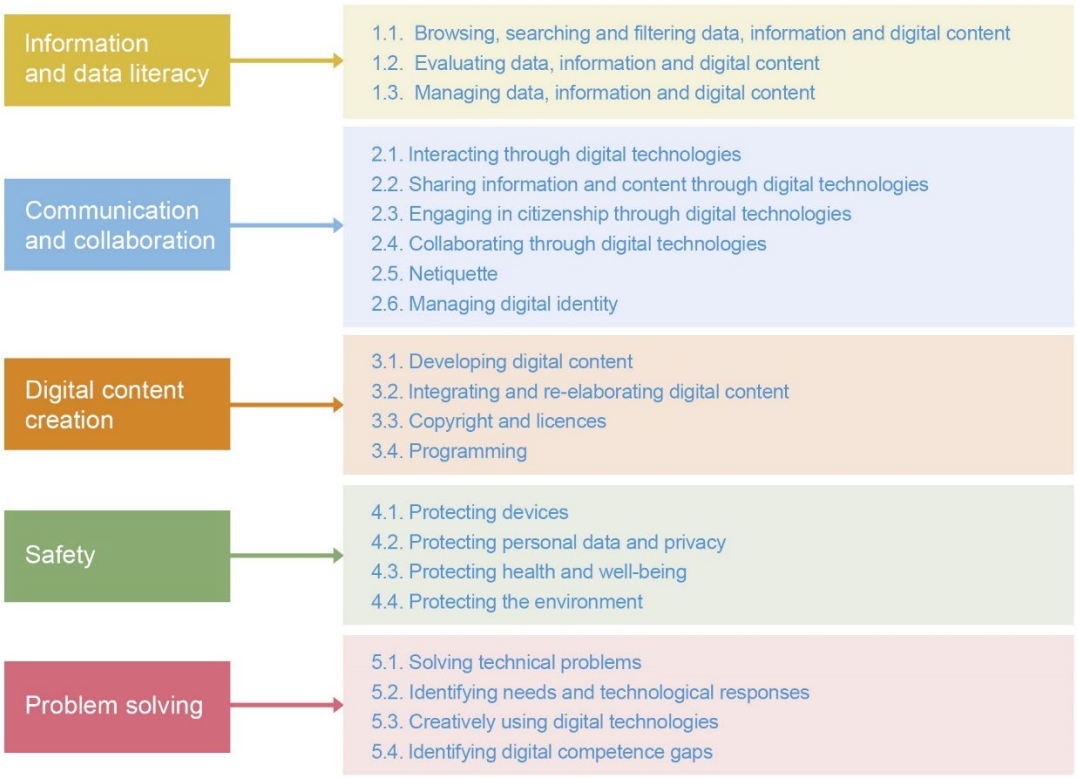
2. Communication and collaboration	To interact, communicate and collaborate through digital technologies while being aware of cultural and generational diversity. To participate in society through public and private digital services and participatory citizenship. To manage one's digital identity and reputation
3. Digital content creation	To create and edit digital content. To improve and integrate information and content into an existing body of knowledge while understanding how copyright and licenses are to be applied. To know how to give understandable instructions for a computer system.
4. Safety	To protect devices, content, personal data and privacy in digital environments. To protect physical and psychological health, and to be aware of digital technologies for social well-being and social inclusion. To be aware of the environmental impact of digital technologies and their use.
5. Problem-solving	To identify needs and problems and to resolve conceptual problems and problem situations in digital environments. To use digital tools to innovate processes and products. To keep up to date with the digital evolution.
6. Career-related competences	To operate specialized digital technologies and to understand, analyse and evaluate specialized data, information and digital content for a particular field.

(2) DigComp 2.2

The 'Digital Competence Framework for Citizens (DigComp 2.2)' is a descriptive reference framework developed by the European Commission to support the development of digital competence among individuals in Europe, enabling them to use digital technologies confidently, critically, collaboratively, and creatively (see Figure 6.6). DigComp provides examples of competence areas and their sub-levels at all stages of development. First published in 2013, it has been regularly updated, with the latest version being DigComp 2.2 in 2022. It comprises five digital competence areas: information and data literacy, communication and collaboration, digital content creation, safety, and problem solving. Each area is further divided into 21 component competencies. DigComp also defines proficiency levels, ranging from foundation to highly specialized, which are further divided into eight levels for in-depth progression criteria. The framework includes definitions of the necessary knowledge, skills, and attitudes, as well

as case examples to support learning materials, assessment, and recognition of learning progression. DigComp has been used in over 20 European countries to support TVET for various occupational groups, including teachers, school staff, museum professionals, social workers, and youth workers. The target audience for DigComp includes policymakers, teachers and trainers, and labour market partners (Vuorikari et al., 2022).

Figure 6.6 The DigComp conceptual reference model



Source: Vuorikari et al. (2022).

(3) DQ (Digital Intelligence) Global Standard on Digital Literacy, Digital Skills and Digital Readiness

The 'DQ Global Standard on Digital Literacy, Digital Skills, and Digital Readiness' is a framework developed by the DQ Institute (see Figure 6.7). This framework is grounded in the concept of 'Digital Intelligence', which includes technical, meta-cognitive, and socio-emotional competencies based on universal moral values. The aim of this framework is to ensure the safety, empowerment, and well-being of individuals, organizations, and nations in the digital age. The standard has received endorsement from

the IEEE Standards Association and the Coalition for Digital Intelligence, which comprises the OECD, IEEE Standards Association, and DQ Institute, in collaboration with the World Economic Forum. The framework is structured into eight areas across three dimensions, resulting in 24 competence areas. These areas include digital rights, digital literacy, digital communication, digital emotional intelligence, digital security, digital safety, digital use, and digital identity. The competencies are categorized into three levels: digital citizenship, digital creativity, and digital competitiveness. Each of the 24 competencies is defined in terms of the knowledge, skills, and attitudes/values that demonstrate competence. Furthermore, these competencies are mapped to other digital competence frameworks. The DQ Institute is also developing a DQ Index to measure nations' level of digital intelligence and is leading a campaign to support 'DQforAll'. The framework's target audience includes policymakers, NGOs, and teachers/trainers (DQ Institute, 2019).

Figure 6.7 DQ (Digital Intelligence) Global Standard on Digital Literacy, Digital Skills and Digital Readiness

Source: DQ Institute (2019).

(4) Other digital competency frameworks for individuals

Other digital competence frameworks relevant to TVET students include 'IC3 Digital Literacy' developed by Certiport (2022) in North America, 'Digital Literacy Skills Framework (DLSF)' developed by the Australian Department for Education, Skills and Employment (2020), 'E-Competence Framework for the ICT Professions' adapted by the World Bank (Bashir, 2020) from the 'European e-Competence Framework', and 'Indonesian National Digital Literacy Framework' developed by the Indonesian Ministry of Communication and Informatics (UNEVOC, 2023b).

6.2.3 Approaches to TVET student competence development for digital transformation

TVET's key commitment is to prepare students for future work and life. Reflecting on the digital competences required for individuals, the specific competence needs of TVET students are considered in the context of digital transformation. Key dimensions of TVET student competence development for digital transformation include:

- **Developing digital literacy**: This involves the ability to effectively use digital tools, navigate online platforms, critically evaluate digital information, and adapt to emerging technologies. Importantly, digitally disadvantaged students, particularly those from low-income backgrounds or rural areas, may require guidance and support from TVET institutions due to their limited access to computers or reliable Internet connections (Helsper & Eynon, 2010).
- **Developing professional digital skills**: TVET students competent in digital transformation should have a solid foundation in digital skills related to their future profession, such as programming, data analysis, information security, network management, and software development.
- **Developing problem-solving and critical thinking skills**: Competent TVET students in digital transformation should possess strong problem-solving and critical thinking skills, enabling them to analyze complex situations, identify issues, and develop innovative solutions using digital technologies.
- **Increasing students' adaptability and flexibility**: Given the constant evolution of digital technologies and industries, competent TVET students should be open

to change, willing to learn new skills, and able to quickly adapt to emerging technologies.

- **Develop collaboration and teamwork skills**: Competent TVET students in digital transformation should have effective collaboration and teamwork skills, enabling them to contribute actively to common goals in digital transformation.
- **Guide ethical and responsible use of technology**: Competent TVET students should comprehend the ethical implications of using digital technologies and exhibit responsible behaviour in their digital interactions. Specifically, they should adhere to ethical standards, respect privacy and data protection, and consider the social impact of their actions.
- **Develop life-long learning skills**: Competent TVET students in digital transformation should possess skills for continuous learning and self-improvement, stay abreast of the latest technological advancements, and engage in lifelong learning (OECD, 2022).

6.4 Summary

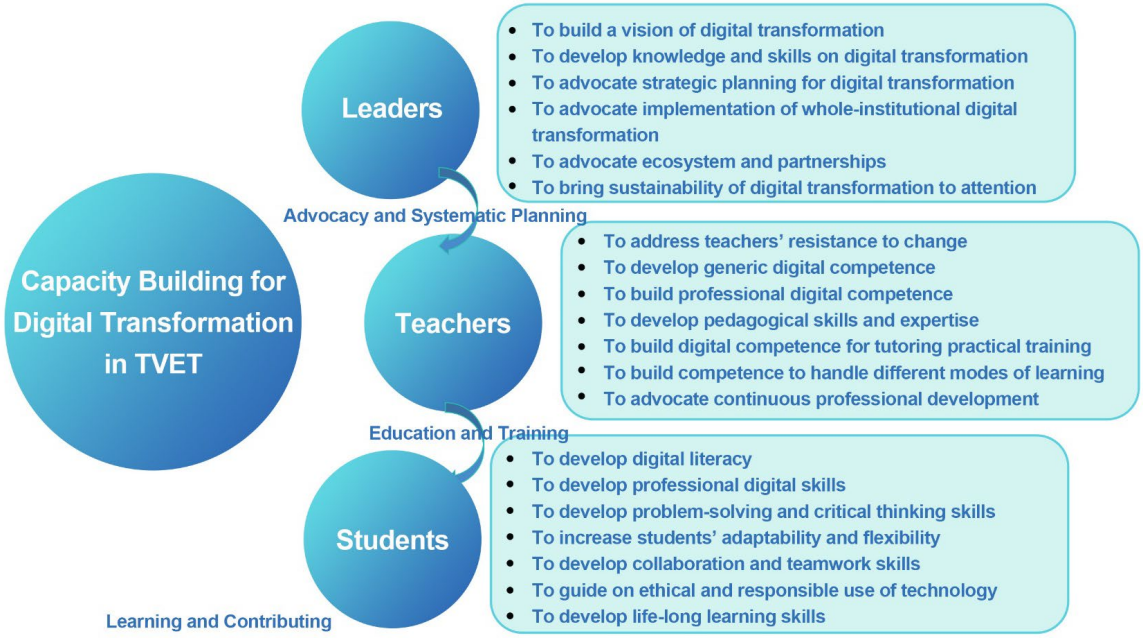
Capacity building for digital transformation is vital to empower the entire TVET system to initiate and implement transformative practices. Leaders, teachers, and students are three key stakeholder groups in the TVET system and are, therefore, the primary targets for capacity building for digital transformation. Based on the analysis of competence development for TVET leaders, teachers, and students in this chapter, Figure 6.8 presents a synthesized framework of capacity for digital transformation in TVET.

Developing TVET leaders' digital transformation competences is essential, as leaders are responsible for driving change and innovation within institutions. TVET leaders must understand the potential of digital technologies and their impact on TVET delivery. Thus, they must develop a vision for TVET digital transformation. They should formulate digital strategies and policies, allocate resources effectively, and create a supportive environment for digital transformation initiatives. Capacity-building programmes for TVET leaders should focus on enhancing their digital transformation vision, strategic thinking and planning, networking and partnership, change and sustainability management, and leadership skills in the context of digital transformation.

Enhancing teachers' capacity for digital transformation contributes to the improvement of teaching, training, and learning. Teachers should not only be proficient

in using digital tools, platforms, and resources to enrich their teaching practices but also be familiar with industry-specific digital technologies. They need to effectively integrate technology into their curriculum, develop digital learning materials, and facilitate online and blended learning experiences. Capacity-building programmes for TVET teachers should aim to improve their willingness to transform, their generic and professional digital competences, their pedagogical skills for technology integration, and their adaptability to new teaching methodologies in the digital age.

Figure 6.8 Framework of capacity building for digital transformation in TVET



Source: Author.

Developing students' competences in digital transformation can help bridge the digital skills gap in the future world of work. The digital competences of students reflect the output of the entire TVTE system, as it is crucial to equip them for the digitalized job market. Students need to develop digital transformation competences that align with industry needs, including digital literacy, professional digital skills, critical thinking, problem solving, creativity, communication, collaboration, and adaptability. Capacity-building programmes for TVET students should focus on providing hands-on experiences with digital technologies, enhancing problem-solving and critical thinking skills,

promoting collaboration and teamwork, guiding ethical and responsible use of technologies, and fostering a mindset of adaptability and lifelong learning.

Notably, the different dimensions of digital transformation capacity building for leaders, teachers, and students are closely interrelated. Specifically, effective digital transformation TVET leaders would advocate and systematically plan for digital transformation. Subsequently, TVET teachers, as effective practitioners, would implement education and training practices well. Eventually, TVET students, as beneficiaries, would acquire digital transformation competences and be prepared to contribute to the future workforce. Given the interrelationships among the three, TVET institutions are recommended to adopt a systematic digital transformation capacity-building approach, paying attention to TVET leaders, teachers, and students. By fostering a transformation ecosystem supported by these three key stakeholders in innovation, TVET institutions can ensure their graduates are well-prepared for the changing job market and contribute to the digital transformation of industries.

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Chapter 7

International Collaboration and Exchange in the Digital Transformation of TVET

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This chapter explores the pivotal role of international collaboration in the digital transformation of Technical and Vocational Education and Training (TVET). It scrutinizes various cooperation models, including collaboration agreements, resource sharing, and cross-national projects that propel digital transformation in TVET. The chapter then elaborates on the collaborative ecosystems linking TVET institutions, industry leaders, and policymakers, underscoring specific initiatives that significantly enhance digital transformation. It also highlights multilateral efforts addressing shared challenges and equipping individuals with the necessary skills for the digital age. Moreover, this chapter underscores the importance of shared digital tools, resource repositories, and case studies in effectively aligning TVET provision with the demands of the digital era.

7.1 Approaches to international collaboration and exchange

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The chapter's focus is to exhibit the collaboration models, mechanisms, and cases employed by various international organizations, countries, and cross-regional agencies in TVET's digital transformation. These collaborative approaches offer practical and effective solutions to facilitate international exchanges in this domain. Common forms of international collaboration and exchange encompass:

- **Collaboration agreements**: Countries may sign agreements to collaborate in the field of digital transformation in TVET, delineating the intentions, objectives, responsibilities, and resource allocations of all parties. These agreements, which can be bilateral or multilateral, standardize collaborative relationships and propel project implementation.
- **Resource sharing**: International collaboration and exchanges can enable the sharing of educational resources, teaching equipment, technology tools, and other assets across borders. Capitalizing on each country's strengths and advantages in digital resources can augment the overall quality and efficiency of TVET provision.
- **International conferences and dialogues**: Organizing international conferences and other dialogue platforms allows policymakers and experts from various countries to exchange ideas and insights on topics related to digital transformation in TVET. This promotes the integration of theory and practice in TVET and provides opportunities to expedite policymaking, strategy development, and practice sharing on digital transformation in TVET.
- **Cross-national cooperative projects**: Initiating cross-national cooperative projects, such as professional digital skills competitions or collaborative innovation research initiatives, can stimulate creativity among TVET students and teachers/trainers, thereby enhancing the quality and international competitiveness of TVET.
- **Collaborative reports and research**: Collaborative reports, like the one produced by the ILO and UNESCO titled *Digitalization of TVET and Skills Systems*, inform stakeholders of the global state of digital transformation and foster a shared understanding of the challenges and opportunities in different contexts.
- **Capacity-building initiatives**: Organizations such as UNESCO, UNESCO Chairs, and UNESCO-UNEVOC network members run several initiatives aimed

at developing countries' capacities in education digital transformation. These programmes may offer training sessions, resources, and expert support to educators and leaders in TVET institutions.

7.2 International platforms and partnerships

This chapter underscores the importance of collaborative partnerships and networks within TVET in fostering the exchange of knowledge, expertise, and resources pertinent to digital transformation. These collaborative ecosystems link TVET institutions, industry leaders, governmental bodies, civil societies, and international organizations. Their primary aim is not only to facilitate the sharing of insights but also to synchronize policies and strategies, thereby advancing the development of digital implementation and innovation in TVET. Some regional and global initiatives and projects, such as the UNESCO-UNEVOC Network and the Global Skills Academy, aim to enhance the digital transformation of TVET systems and practices.

7.2.1 UNESCO's commitment to advancing ICT in education

UNESCO connects education to the rapidly evolving world of work through its promotion of skills for work and life. TVET assists youth and adults in developing the abilities, knowledge, values, and attitudes necessary to secure decent work and contribute to building a peaceful, healthy, just, and sustainable world. TVET contributes to the targets of Sustainable Development Goal (SDG) 4 to 'ensure inclusive and equitable quality education and promote lifelong learning opportunities for all' and those of SDG 8 for 'decent work and economic growth'. At UNESCO's Headquarters, the Section for Youth, Literacy and Skills Development spearheads the work on TVET. As the leading organization for education in the United Nations, UNESCO guides international efforts to accelerate progress towards SDG 4 through the use of ICT in education. This vision is encapsulated in the Qingdao Declaration, the first global declaration on ICT in education. The Qingdao Declaration on ICT in Education was ratified at the conclusion of the conference on ICT for the 2030 Education Agenda held in Qingdao, China. The Declaration delineates how technology can be utilized to achieve educational targets for equity, access, quality, and lifelong learning in the context of the SDGs. In the Qingdao

Declaration, UNESCO advocated for the execution of three initiatives to support international cooperation in digitalization in education post-2015:

- **Establishing an international fund**: This initiative aims to assist developing countries, especially the least developed ones, in utilizing ICTs to achieve national educational goals.
- **Setting up an educational global network**: This network is designed to share professional skills and knowledge in educational digitalization, benefiting policymakers, researchers, and teachers.
- **Constructing information-sharing institutions**: These institutions are intended to share successful practices and experiences in educational innovation supported by technology.

These three initiatives provide a global platform and service to promote educational equity and quality, advancing international cooperation to create a more digital landscape of TVET

7.2.2 UNESCO-UNEVOC and the UNEVOC Network

The UNEVOC Network, coordinated by UNESCO-UNEVOC, is a global assembly of institutions specializing in TVET. Comprising over 220 UNEVOC Centres across more than 140 UNESCO Member States, these centres encompass ministries, national bodies, training providers, and research institutions dedicated to TVET in their respective countries and regions. The network's objective is to enhance the standards and quality of TVET in alignment with the SDGs and the *UNESCO Strategy for TVET (2022–2029)*. It also advocates for the evolution of innovative and inclusive TVET systems that cater to the requirements of learners, employers, and society.

The UNEVOC network, a crucial partnership outlined in the *UNESCO Strategy for TVET (2022-2029)*, is set to expand its reach and influence through a series of strategic activities. These initiatives aim to fortify cross-border, cross-level, and cross-institutional collaborations among national education ministries, national TVET management agencies, higher education and research institutions, and TVET institutions. This is achieved by sharing best practices and enhancing TVET governance. The network fosters an environment conducive to exchange, cooperation, and mutual assistance among its members and organizes various activities and events, such as the TVET Leadership

Programme, the Skills in Action Photo Competition, and the UNEVOC Network Spotlight events.

Acknowledging the escalating significance of digital transformation in TVET, the UNEVOC network connects its global members through several capacity-building programmes. These programmes are designed to equip teachers, administrators, and policymakers with a better understanding of the trends and issues surrounding digital transformation in TVET. Furthermore, the network promotes knowledge sharing on digital transformation through various activities and events, such as workshops and online communities, with a particular focus on reaching the most disadvantaged and fragile TVET systems worldwide. Through its extensive network, it cultivates a collaborative ecosystem where expertise, experiences, and insights related to digital transformation can be shared and amplified.

7.2.3 UNESCO Chair on Digitalization in TVET

Launched in 2022, the UNESCO Chair on Digitalization in TVET is a novel initiative by UNESCO in collaboration with Shenzhen Polytechnic University. The Chair concentrates on the theme of Digitalization in TVET and strives to foster digital transformation in TVET at global, regional, and country levels. The work of the Chair aligns closely with the recently launched UNESCO Strategy for TVET (2022–2029).

Adhering to the principles of 'Extensive Consultation, Joint Contribution and Shared Benefits', the UNESCO Chair on Digitalization in TVET has initiated South-South cooperation and multi-partner cooperation, leading to the execution of six sub-programmes. These include the development of theories of digitalization in TVET, the creation of education programmes and teaching and learning resources in the discipline of digital technologies, the promotion of digital transformation of traditional TVET programmes, the development of generic digital skills qualifications, and the subsequent update of curriculum syllabuses. It also aims to establish a smart campus and virtual training ecosystem and develop new education/training technologies and digital pedagogies. Through training, it seeks to enhance the capacity of TVET teachers and the leadership of leaders for digital transformation. With these efforts, the Chair aspires to bridge digital divides, ensure equitable quality education, promote lifelong learning, and foster global socioeconomic sustainable development.

7.3 Typical programmes of international collaboration

7.3.1 Global Education Coalition

Established by UNESCO in March 2020, the Global Education Coalition (GEC) was formed to address the educational challenges amplified by the COVID-19 pandemic, which resulted in worldwide school closures and exacerbated existing educational inequalities. The GEC is an open platform that unites partners from diverse sectors to alleviate educational disruptions by rallying support around three key themes: Connectivity, Gender, and Teachers. Operating as a demand-driven network, the GEC comprises engaged members and key educational stakeholders striving to transform education at all levels. UNESCO's role within the coalition is to facilitate cooperation, foster synergies, and match the needs of countries with the resources and services of Coalition Members.

The GEC includes partners such as private sector members, multilateral organizations, non-governmental organizations, civil society actors, networks and associations, and international media organizations. From 2020 to 2023, the Coalition has made significant strides in forging effective partnerships that have yielded tangible impacts across all levels of the educational ecosystem and in various regions, countries, and contexts. It has assisted over 615,000 youths in developing employability skills, trained 654,796 teachers, supported over 800,000 learners studying foundational subjects such as STEM, and reached 1,880,552 of the most marginalized girls and women (UNESCO, n.d.).

Beyond the pandemic, the GEC has demonstrated its effectiveness in responding to crises, gaining valuable experience and fostering stronger ties among Coalition Members that can fuel the scaling of its ambitions. The Coalition now has the opportunity to support countries in their digital transformation endeavours. Over the past few years, the focus has shifted from responding to COVID-19 to bolstering the resilience of educational systems in various crisis situations and advancing educational transformation. At the Transforming Education Summit in September 2022, several Coalition partners convened to establish the foundations for the Digital Transformation Collaborative, a subgroup of the Coalition. This subgroup will work directly with countries to co-create sustainable plans for large-scale digital transformation. As the Coalition transitions from a pandemic response to a transformation agenda in 2023 and beyond, this group will facilitate the

formation of bold, scalable, and sustainable partnerships. These collaborations aim to harness the power of digital transformation, bridge educational divides, and support actions and investments for pilot projects to be scaled up at a national level in a sustainable manner.

7.3.2 Global Skills Academy

The Global Skills Academy (GSA), an initiative within UNESCO's GEC, aims to empower 10 million youths and adults worldwide by 2029. Its primary goal is to enhance employability and resilience by equipping individuals with the necessary skills. The Academy collaborates with over 230 TVET institutions worldwide, facilitated through UNESCO and the UNEVOC network, to foster essential 21st-century skills, including digital, entrepreneurial, and green skills. It tailors its training to meet the rapidly evolving labour market's demands, ensuring skilling, upskilling, and reskilling opportunities are provided. The Academy prioritizes digital skills, recognizing their importance in the contemporary digital era. In partnership with influential entities such as Microsoft, IBM, Huawei, and Coursera, the Academy offers a range of impactful online training programmes in ICT skills, entrepreneurship, and sustainability.

The Academy's association with the Huawei ICT Academy is particularly noteworthy. It imparts Huawei ICT training and certifications and reaches an extensive audience of over 150,000 ICT Academy students annually across more than 1900 academies in 110 countries. The GSA supports educators in integrating digital skills into pedagogical approaches, standing as a driving force in advancing global employability and resilience through skill cultivation. The GSA serves as a pivotal international platform for digitalization in TVET, fostering essential digital competencies through strategic partnerships and tailored training initiatives.

7.3.3 UNESCO-UNEVOC's Digital Transformation Programme

The UNESCO-UNEVOC International Centre, a specialized United Nations agency, promotes TVET for sustainable development. One of its key thematic areas is digital transformation, aiming to enhance the capacity of TVET institutions to respond to the digital era's challenges and opportunities. The project provides a knowledge hub containing information, examples, and discussion papers on local, national, regional, and

international levels' efforts to address the challenges TVET providers, teachers, and learners face in the digital transformation of TVET provision.

The UNESCO-UNEVOC's digital transformation programmes consist of four sub-projects in 2022–2023:

- **TVET Teachers' and Trainers' Digital Skills Development**: This sub-project identifies and analyzes global trends, key data, good practice examples, and case studies on digital skills training for TVET teachers and trainers.
- **Digital Competence Frameworks for Teachers, Learners, and Citizens**: This sub-project provides a repository of digital competence frameworks and discusses their features, advantages, and constraints for TVET contexts.
- **Toolkits for TVET Providers**: This sub-project offers toolkits to support TVET providers in identifying their needs and assessing their progress in TVET priorities, such as digitalization, greening, inclusion, and entrepreneurship.
- **Open Educational Resources**: This sub-project explains what OERs are and how they can be accessed and offers a list of OERs relevant to TVET teachers and learners.

These projects, co-developed and contributed by national bodies, TVET institutions, UNEVOC centres, UN agencies, industry partners, individual experts, and researchers from different regions, support the UNEVOC global network for TVET institutions by providing guidance on ensuring inclusive, equitable, and quality TVET delivery in the process of digital transformation.

7.3.4 BILT initiative by UNESCO-UNEVOC, BIBB, and BMBF

The 'Bridging Innovation and Learning in TVET (BILT)' is a collaborative initiative of UNESCO-UNEVOC, the German Federal Institute for Vocational Education and Training (BIBB), and the German Federal Ministry for Education and Research (BMBF). The project's objective is to foster modern and competitive qualifications and competencies in TVET through international innovation and learning. This mission is realized through peer learning and knowledge exchange among European, Asian, and African TVET institutions, with good practices and lessons learned disseminated to other interested TVET stakeholders.

The BILT project addresses current challenges in TVET systems stemming from technological, social, environmental, and workplace changes. It provides a platform for

efficiently identifying new qualifications and competencies, integrating them into appealing curricula and training regulations, and implementing them through innovative pedagogical approaches (the 3I's approach). The project emphasizes new digital skills and competencies, trends in digital skills training for teachers and trainers, and the impacts of digitalization on TVET. BILT focuses on the dual transition of digitalization and greening, including conferences on digitalization in TVET where professionals discuss sector trends and exchange information on innovation and learning techniques. The BILT Learning Labs showcase selected innovation and learning practices, some of which specifically focus on digitalization, offering TVET practitioners a platform to share innovative ideas and engage in discussions with the TVET community.

7.3.5 'Digitalization, AI and the Future of Work' by CEDEFOP

The European Centre for the Development of Vocational Training (CEDEFOP) is an EU-funded agency that has been instrumental in advancing European vocational education and training (VET) policies since its establishment in 1975. CEDEFOP serves as a robust knowledge hub, providing a suite of online tools, databases, and evidence-based scientific outputs.

One of CEDEFOP's significant international initiatives related to digitalization in TVET, known as the 'Digitalization, AI and the Future of Work' project, is dedicated to analyzing the impact and driving forces of digitalization and automation on employment comprehensively. It also examines the resultant shifts in skill requirements and potential skill mismatches within the workforce. Additionally, this project explores the implications of digitalization for emerging forms of work and learning, such as platform or gig work and remote ICT-based work. Through its research, CEDEFOP aims to provide valuable insights that inform policy development concerning the future of TVET in the context of the ongoing digital revolution. By harnessing comparative analyses and leveraging knowledge gathered from extensive research and networking, CEDEFOP contributes effectively to enhancing both initial and continuing VET, as well as aspects of lifelong learning within the European landscape.

7.4 Collaborative sharing of tools, resources, and promising practices

7.4.1 Collaborative sharing of tools and resources

TVET institutions must adopt innovative approaches and technologies, and collaborate with other stakeholders to share tools, resources, and best practices. The collaborative sharing of tools and resources is crucial for the digital transformation of TVET. It allows TVET institutions to pool their resources, reducing the financial burden and providing access to advanced technologies, which is particularly beneficial for underfunded educational systems. Moreover, collaboration encourages the exchange of knowledge, innovative practices, and the customization of digitalization strategies to meet local needs.

UNESCO-UNEVOC has compiled a list of online tools and resources to assist TVET providers/practitioners in assessing their performance and reflecting on aspects of their provision. The 'Toolkits for TVET Providers' (UNESCO-UNEVOC, 2023b) share tools and resources with different purposes and themes, such as helping TVET providers and practitioners to reflect on their performance, digitalize their operations, green their practices, and promote inclusivity. Some of the toolkits available under the theme of digitalization are:

- ***AI and Education: Guidance for Policy-Makers (2021)*** prepared by UNESCO: A toolkit that provides guidance to policymakers on how to leverage AI in education.
- ***Syllabuses of Digital Programs in TVET (2022)*** prepared by Shenzhen Polytechnic University: This guidebook contains 28 digital programmes grouped into six clusters, implemented at Shenzhen Polytechnic University in China. It is designed to assist global TVET institutions in developing digital technology programmes. The guidebook includes tools like programme syllabuses, operational guidelines, management tools, and curriculum design, targeting TVET programme developers, teachers, trainers, and managers worldwide.
- ***Digital Skills Toolkit*** prepared by the ITU: A toolkit that provides TVET providers with guidance on developing a digital skills strategy.
- ***SELFIE for* Work-based Learning** prepared by the European Commission: SELFIE for work-based learning (WBL) is a free online tool that supports vocational education and training (VET) schools and companies to make the most of digital technologies for teaching, learning and training.

- ***OER Toolkit: Course Design and Materials Development Guide*** prepared by OER Africa and Saide (2022): It is a toolkit that provides guidance and resources for educators and designers to design a course or develop materials using OER.

7.4.2 Collaborative sharing of promising practices

Case studies on the topic of digital transformation in TVET are valuable sources of information and inspiration for educators, policymakers, and practitioners. They provide insights into the challenges and opportunities of integrating digital technologies into TVET practices, including the impact and outcomes of such interventions. Case studies also showcase good practices, lessons learned, and recommendations for improving the quality and relevance of TVET in the digital era. By sharing and analyzing case studies on digitalization in TVET, stakeholders can learn from each other's experiences, identify gaps and needs, and foster collaboration and innovation.

(1) UNESCO-UNEVOC

UNESCO-UNEVOC has compiled a database of 'Innovative and Promising Practices' (UNESCO-UNEVOC, 2023a), which encompasses innovative, sustainable, and replicable practices in the field of TVET. These practices, which can be projects, policies, plans, or activities in various areas such as education, training, and employment, are implemented at national, regional, or global levels with the objective of enhancing TVET's quality, efficiency, and impact. The database, accessible on the UNEVOC website, serves as a platform for the global TVET community to share and learn about innovations and best practices in TVET.

The database houses over 200 case studies from around the world, covering a broad spectrum of topics including digitalization, greening TVET, entrepreneurship, new qualifications and competencies, gender equality, and more. It demonstrates how TVET can be designed and delivered to address contextual challenges, presents the conditions enabling success, and provides a snapshot of the positive community impact. The database includes numerous practices related to digitalization in TVET, all categorized under the theme of 'Digitalization and the Future of TVET'.

(2) UNESCO Chair on Digitalization in TVET

The UNESCO Chair on Digitalization in TVET has released a comprehensive guidebook detailing 28 digital TVET programmes, categorized into six programme clusters, implemented at Shenzhen Polytechnic University, China. This resource, a collection of promising practices, offers valuable assistance to global TVET institutions aiming to develop emerging digital technology TVET programmes.

Furthermore, the Chair is gathering and disseminating a series of promising practices and cases on various themes of TVET digital transformation. The initiative, led by the Chair, advocates for the digital transformation of TVET, showcasing leadership in areas such as TVET programme transformation, curriculum design, the application of EdTech, innovative teaching methods, advanced teaching platforms, and the development of practical training facilities. This initiative aims to provide empirical experiences that serve as practical guidance for both academia and practitioners in the TVET community.

7.5 Summary

This chapter presents a comprehensive framework of identified pathways, platforms, programmes, and tools. The showcased collaborative models suggest a future where the entire TVET system integrates seamlessly with the digital era. As we look ahead, the digital transformation of TVET will continue to benefit from international platforms and partnerships. Institutions such as UNESCO and UNEVOC will significantly advance TVET digitization through their advocacy. Initiatives and cross-border programmes, including the *GEC* and the *GSA*, will actively contribute to reducing the digital divide, enhancing TVET quality, and fostering skills development. Furthermore, the collaborative sharing of tools, resources, and best practices will empower TVET institutions to adapt better to the digital era's demands, thereby promoting innovation, collaboration, and sustainable development.

To harness these advancements globally, global TVET governance bodies, institutions, and research organizations must engage in extensive collaboration. Utilizing platforms provided by international organizations such as UNESCO, and contributing to and benefiting from digital transformation tools, will advance the global agenda for TVET digital transformation. Future collaborations should focus on the development of digital technologies, the global accessibility of TVET, and the relentless pursuit of the SDGs on a global scale.

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Chapter 8

Challenges, Trends, and Recommendations

Wenxi Wu

The landscape of Technical and Vocational Education and Training (TVET) is undergoing a significant transformation driven by the proliferation of digital technologies. This digital transformation, while promising to revolutionize TVET and stimulate economic development and innovation, is not without challenges. It presents unique hurdles such as a persistent digital divide and the ongoing need for programme updates in line with industry advancements. This report's final chapter identifies these challenges faced by the TVET system and institutions during digital transformation. It outlines emerging trends shaping TVET's future and concludes with recommendations to enhance TVET institutions' digital capacities.

8.1 Challenges

8.1.1 Insufficient funding for digital infrastructure

The digital transformation of TVET involves integrating digital tools and technologies into educational processes and creating a dynamic, connected, interactive learning environment adaptable to individual learners' needs. This transformation necessitates the

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X. Yang & W. Yang (Eds.), *Digital Transformation in Global TVET: Methodology and Practices*. UNESCO Chair on Digitalization in TVET.

establishment of a robust digital infrastructure. However, securing adequate funding for this infrastructure poses a challenge. Digital infrastructure encompasses a wide range of elements essential for digital learning, including robust Internet connectivity capable of handling advanced tech applications, software applications supporting Learning Management Systems (LMS), interactive learning communication platforms, and safety and security systems such as firewalls. It also involves investment in digital devices, hardware, and servers for data storage solutions.

Addressing TVET's multifaceted digital needs imposes significant budgetary demands, which can be daunting for educational institutions, particularly in under-resourced regions. There is a notable funding deficiency in developing countries, with current investment falling short of what is needed to bridge the digital divide. A report by the Broadband Commission for Sustainable Development (2019) states that achieving universal broadband connectivity in Africa by 2030 requires an annual investment of more than $100 billion. The COVID-19 pandemic has exacerbated the digital divide, particularly in regions such as the Asia-Pacific and Africa. As governments redirect funds to address the health crisis, the funding deficit for digital infrastructure widens, underscoring the urgent need for increased funding.

Moreover, the necessary investments extend beyond the initial setup of this digital infrastructure. They also cover ongoing costs, including maintenance, upgrades, workforce training for efficient technology use, and the development of digital pedagogical tools for educators. Therefore, implementing a substantial digital transformation requires significant financial resources, making funding the primary obstacle in this process.

8.1.2 Widening of the digital divide in regional and national TVET

'Digital divide' refers to the disparity in access to, use of, or knowledge of information and communications technology (ICT) among individuals, households, businesses, or geographical areas at varying socioeconomic levels. As digital transformation advances, this divide has become more pronounced.

UNESCO (2023, p. 3) posits that 'the right to education is increasingly synonymous with the right to meaningful connectivity, yet access is unequal.' While developed nations are swiftly reaping the benefits of digitalization, under-resourced regions, particularly in parts of Asia and Africa, often lag behind. According to the International

Telecommunication Union (ITU) (2020), Internet penetration reached approximately 87% in developed countries, but was significantly lower in less developed regions, standing at 47% in developing countries and a mere 19% in the least developed countries. The Digital Skills Gap Index 2021 (Wiley, 2021) reveals that only a few countries, such as Canada and the United States, are satisfied with the current state of digital skills proficiency. Other regions continue to experience a mismatch between employers' needs and job seekers' digital abilities, indicating the need for robust digital literacy programmes to bridge this gap.

Research within nations also highlights substantial inequalities in digital education preparedness based on geographical location, gender, and socioeconomic background. For instance, a 2021 report by the Pew Research Center found that 85% of urban Americans and 79% of suburban Americans reported having a broadband Internet connection at home, compared to 65% of rural residents (Vogels, 2021). In African countries, the disparity is even more pronounced. For example, in Kenya, as of 2020, only 13.7% of the rural population had Internet access, compared to 42.5% in urban areas (Mabele et al., 2022). These figures reflect not only infrastructural weaknesses but also socioeconomic inequalities.

In the context of TVET, the divide is more pronounced due to several factors. Firstly, TVET programmes often rely heavily on hands-on training using profession-specific technologies. Access to such technologies can be limited in many under-resourced regions, thereby widening the digital divide. Secondly, even with access to technology, the lack of necessary digital skills can hinder its effective use. This often extends beyond basic digital literacy to include specialized digital skills related to specific vocations, exacerbating the digital divide in a TVET context. Thirdly, the shift to online learning, expedited by the COVID-19 pandemic, has highlighted the digital divide. While higher education institutions may have the resources to transition to online learning, TVET institutions, particularly in developing countries, often struggle due to a lack of infrastructure, resources, and expertise. Infrastructure needed for digital access, such as reliable electricity and Internet connections, is unevenly distributed among different types and levels of institutions.

In fact, the digital divide is two-pronged: it not only limits students' access to digital tools necessary for learning but also hinders them from acquiring essential vocational and technical skills needed in an increasingly digitalized job market. This divide deepens

existing socioeconomic inequalities between those who have access to digital learning and those who do not. Thus, addressing this divide is key to ensuring that TVET students, regardless of their socioeconomic background or geographical location, can acquire the digital skills needed in an increasingly digitalized world.

8.1.3 Digital skills training for disadvantaged groups

In the TVET context, disadvantaged groups may encompass individuals and communities historically marginalized or disadvantaged for various socioeconomic factors. These factors can span economic status, gender, disability, race, ethnicity, and geographical location. In the digital domain, these disadvantages can result in restricted access to digital resources and lower levels of digital literacy and skills.

Disadvantaged groups generally exhibit lower rates of digital literacy compared to the broader population. Although specific data fluctuate by region and the group under consideration, the ITU (2022) indicates that 66% of the global population utilized the Internet in 2022. However, this rate drops to a mere 36% in the least developed countries. This digital access gap, and the ensuing digital skills gap, are further amplified within disadvantaged groups in these regions.

The provision of digital skills training for disadvantaged groups is a critical priority for several reasons. First, as we transition towards a more digital world, these skills become increasingly essential for employment across a broad spectrum of sectors. Ensuring these groups acquire such skills enhances their employment prospects and contributes to socioeconomic empowerment. Second, digital skills can facilitate greater social inclusion by providing access to information, services, and opportunities that might otherwise be inaccessible. Third, equipping disadvantaged groups with digital skills can bridge the broader digital divide, creating more equitable opportunities for all. Therefore, targeted initiatives and policy measures focusing on digital skills training for these groups are vital to building a more inclusive digital economy and society.

8.1.4 Skills mismatch and the need for upskilling and reskilling

Amid the rapid digital transformation, the nature of work across various professions and sectors is evolving. Skills in demand a few years ago are no longer sufficient in today's digital economy, making lifelong learning and continuous upskilling paramount.

According to a report from the World Economic Forum (2023), it is projected that the skills of 44% of the workforce will be disrupted in the next five years. By 2027, 60% of workers will require training, yet currently, only half of them are perceived to have adequate access to the necessary training opportunities. Another report by consulting firm AlphaBeta (2022) urgently calls for training an additional estimated 86 million workers, equivalent to 14% of the existing total workforce, in digital skills across seven Asian countries, including Australia, India, Indonesia, Japan, New Zealand, Singapore, and South Korea, within the next year. The report highlights proficiency in the use of cloud-based tools and cybersecurity skills as the most critical areas for workforce development in the fast-paced digital era. This emphasizes the importance of lifelong learning and the need for regular reskilling and upskilling initiatives to adapt to an ever-evolving, digitally connected world. For developing regions like Asia and Africa, the impact could be more profound, given their rapidly expanding digital economies. With the current trends in digital transformation, it is crucial that employees continually focus on reskilling and upskilling to keep pace with the evolving digital workplace.

8.1.5 Lack of institutional strategic planning

A key challenge for TVET institutions in the digital transformation process is the lack of comprehensive strategies or plans to integrate digital technologies into their educational and managerial frameworks. This deficiency is crucial; without a clear, systematic digital strategy, TVET institutions may find it difficult to implement, manage, and scale up digital initiatives systematically. This strategic shortfall can hinder the effective adaptation of curriculum, pedagogy, and staff professional development to meet the requirements of the digital age.

Organizations such as the International Labour Organization (ILO) (2021) and UNESCO (2023b) emphasize the critical role of strategic planning in the digital transformation of TVET institutions, advocating for a structured and intentional approach. The success of digital initiatives in TVET hinges on the creation of strategies integrated with actual pilot programmes to demonstrate their effectiveness. It is emphasized that for digital transformation to be coherent and deliver its intended benefits, it must be uniformly adopted across TVET institutions and tailored to each institution's unique demands. Moreover, strategic planning should encompass the retooling of training and curricula, investment in infrastructure, and the assurance of inclusivity and equity in

digitalization efforts. This coherent, system-wide strategy enables TVET institutions to leverage technology, modernize education, and prepare students for today's digitalized labour market, aligning with broader goals to promote decent work and lifelong learning opportunities.

8.1.6 Urgency to enhance the digital competences of TVET leaders and teachers

Enhancing the digital competences of leaders and teachers is a pressing challenge for TVET institutions in the face of digital transformation. This challenge is particularly pronounced as TVET leaders and teachers often exhibit lower levels of digital capacity compared to their counterparts in larger, academically-focused universities.

The 'European Framework for the Digital Competence of Educators (DigComp-Edu)' emphasizes the necessity of educators' digital competencies for effective teaching and learning (Redecker & Punie, 2017). However, the benchmark set by this framework often exposes a digital competence gap among TVET practitioners, which is crucial for integrating digital tools and methodologies into TVET teaching and learning. Furthermore, a report by UNESCO (2023b) underscores that the lack of digital competencies among TVET teachers directly affects the quality and relevance of TVET. This gap is particularly concerning given the demand for a workforce capable of operating in increasingly digitalized industrial environments. Such a situation calls for urgent attention, as digital competences are considered one of the core skill sets required in the 21st century and are crucial for fostering innovation and growth within economies. Elevating the digital competences of TVET leaders and practitioners is an urgent challenge that requires the concerted efforts of policymakers, education leaders, and industry partners.

8.1.7 Insufficient digital training environment

TVET institutions face a significant challenge in the digital age: providing a training environment that not only integrates modern digital technologies but also mirrors the realities of increasingly automated and digitized industries. Often, these institutions trail behind the technological curve, delivering educational experiences disconnected from the digital competencies required in modern workplaces.

Numerous studies highlight the disparity between the current training environments in TVET and the needs of a workforce evolving with swift technological advancements (Arthur-Mensah, 2020). Research indicates that TVET educators frequently lack the digital and pedagogical skills necessary for digital transformation, resulting in a mismatch between the skills taught and those demanded by the labour market (Apriana et al., 2019). Despite a universal push for digitalization, many TVET institutions are technologically deficient compared to the changing industry, emphasizing the need for substantial upgrades to establish an effective digital learning ecosystem.

The responsibility of TVET leaders and educators is to acknowledge the crucial importance of digital training environments that are not only technologically sufficient but also pedagogically dynamic and tailored to the specific skills employers seek. This necessitates strategic investment in the latest digital tools and infrastructure, curriculum reform to incorporate digital literacy, and ongoing professional development for educators to proficiently use digital platforms in teaching. Bridging this technological and educational gap involves more than just access to resources; it requires a deeper recognition of the essential role of digital fluency in shaping future workforces.

8.1.8 Data privacy and security

As TVET institutions utilize digital resources, online platforms, and cloud-based systems for remote learning and administrative purposes, they generate, process, and store a vast amount of data online. This data often encompasses sensitive information such as personal identification details, students' academic records, and other confidential institutional data. In the context of digital transformation in TVET, ensuring data privacy and security is a multifaceted challenge involving technological safeguards, legal frameworks, and institutional policies.

The swift pace of digital transformation frequently outstrips the development of corresponding data protection measures. For example, as TVET institutions transition to remote learning in response to the COVID-19 pandemic, the adoption of digital platforms and technologies has accelerated. However, a report from the *Harvard Business Review* suggests that every business shifting operations online faces potential privacy pitfalls that could be highly damaging if mismanaged (Kieran, 2020). Unfortunate incidents such as data breaches can result in significant losses, both financially and in terms of the institution's reputation. Therefore, it is critical for TVET institutions to implement robust

data privacy and security measures to prevent unauthorized access and protect sensitive information.

Steps such as regular data audits, data encryption, secure data storage solutions, and staff training on data safety protocols are moves in the right direction. Additionally, it is vital to have robust policies that comply with global and regional data protection regulations. Clear guidelines on data management, access, storage, and sharing can help ensure data security while also respecting individuals' rights to privacy. These measures are crucial in maintaining trust and confidence among students, staff, and other stakeholders.

8.2 Trends

8.2.1 Transformative impact of AI on TVET

Artificial intelligence (AI), particularly generative AI (GenAI) models like ChatGPT, is revolutionizing all educational sectors. GenAI enhances the capabilities of traditional AI applications and is characterized by its ability to autonomously generate new content in response to prompts. This unique capability makes GenAI particularly useful to educators in various aspects, while also introducing previously unanticipated controversies and challenges.

On one hand, GenAI can significantly assist educators in designing and organizing course materials, creating customized and dynamic lesson plans that cater to students' individual needs, and providing virtual tutoring environments where students receive real-time feedback and support. On the other hand, the technology raises substantial ethical concerns. For instance, the creation of personalized learning resources by AI may inadvertently reinforce biases within algorithms. The lack of real-world understanding by AI models can lead to the production of a seemingly convincing text that contains errors and potentially harmful statements. The perception that AI understands the text it uses can lead both educators and students to place undue trust in the AI's output, posing a risk to educational outcomes. Concerns over data privacy and security are also prevalent (UNESCO, 2023b).

Given these caveats, the thoughtful and ethical implementation of AI in the realm of TVET can invigorate the field with innovative solutions for adaptive learning and

enhanced engagement. Below are some key areas that showcase AI's impact on transforming educational methodologies and outcomes within the TVET sector:

- **Personalized learning**: With the evolution of AI, the paradigm of 'one size fits all' is quickly becoming outdated, giving way to educational experiences tailored to the unique needs and learning styles of individual students. AI-enabled technologies in TVET have the potential to implement personalized learning at scale, considering each student's pace, progress, and performance. By analyzing a student's individual learning behaviour, AI can tailor not just the pace, but also the content and method of instruction to best suit each learner. For TVET students, who often need to master specific practical skills, a customized learning path can be particularly beneficial. This can lead to improved educational outcomes, as each student receives the support and resources they need to succeed.
- **Precision teaching**: AI enables precision teaching, a methodology that uses detailed data analysis to optimize educational strategies. By documenting a student's interactions with educational material through adaptive learning platforms, AI can provide comprehensive feedback and analysis to educators. This helps them understand instructional effectiveness at a granular level, allowing for adjustments that improve teaching outcomes. Furthermore, AI can assist in developing competency-based modules that correlate with industry requirements, enabling educators to dedicate attention to the nuances of each learner's needs and optimizing the teaching process for better outcomes and greater efficiency. In TVET, where the acquisition of precise professional competencies is the goal, such targeted enhancements in teaching methods can be especially valuable.
- **Automated assessment feedback**: Educators can leverage sophisticated algorithms to automate the evaluation of student performances by integrating AI-driven assessment tools, providing accurate, objective, and real-time insights into each learner's comprehension and capabilities. These AI systems extend beyond simple grading; they analyze patterns in responses to diagnose a learner's specific challenges, enabling the provision of personalized interventions that reinforce concepts and fill knowledge gaps. Furthermore, AI can analyze assessment results to identify trends and patterns in student performance, providing insights for future instruction.

- **Augmented training through simulations**: In the field of TVET, augmented reality (AR) and virtual reality (VR) simulations, powered by AI, create lifelike training environments that emulate the complexities of real-world applications. These technologies provide students with opportunities to practice and refine their skills in various scenarios without any associated physical or safety risks. For instance, AR and VR can simulate industrial work settings, allowing trainees to practice machinery operations, safety protocols, and troubleshooting without immediate access to a physical work site.
- **Job market alignment**: Anticipating job market needs is crucial for TVET programmes to ensure graduates possess skills relevant to current and future employment opportunities. AI can effectively align the TVET curriculum with market demands by analyzing job trends and predicting skill requirements. As AI identifies growth areas and industries, TVET programmes can adjust their offerings to prepare students for in-demand jobs, thereby ensuring the continued relevance of the training provided.

As these examples illustrate, AI holds the promise to transform learning experiences, introducing a sophisticated level of personalization and adaptability previously unattainable. This makes learning more engaging, efficient, and effective. For educators, particularly, using AI-powered tools leads to a significant reduction in administrative burdens related to grading and assessments, freeing up time for more meaningful interactions with students. It encourages a shift in focus towards facilitating high-level cognitive skills—such as critical thinking and creative problem solving—thereby nurturing a more dynamic and interactive educational atmosphere.

8.2.2 Emerging learning modalities

In addition to AI, various digital technologies have introduced new learning modalities that cater to the diverse needs of students, promoting inclusivity and adaptability. These emerging modalities are transforming the educational experience by providing innovative pathways for knowledge acquisition and skill development.

- **HyFlex learning**: HyFlex or hybrid-flexible learning model grants students the autonomy to choose between attending sessions in person, participating online in real time, or engaging with course materials at a time that suits their schedule (Pelletier et al., 2023). HyFlex courses are meticulously designed to ensure that

learning outcomes are consistent across all modalities, while the methods of engagement may vary. This approach accommodates different learning preferences and personal circumstances, making education more accessible and student-centred. An effective HyFlex model in TVET may offer both synchronous and asynchronous online options, ensuring that students can engage with their vocational training without being hindered by geographic, temporal, or personal constraints.

- **Ubiquitous learning**: Ubiquitous learning, or U-learning, extends the boundaries of the classroom to include the learner's environment, making educational opportunities available anywhere and at any time. Enabled by the proliferation of Internet-connected devices and platforms, ubiquitous learning leverages the seamless integration of technology into our daily environments to provide a context-aware, personalized learning experience. It underscores the concept that learning can occur in synchrony with the learner's life, supported by mobile technology, pervasive computing, and cloud-based services, fostering a lifelong learning mindset that is not confined to formal educational settings.
- **Robot-assisted learning**: Robot-assisted learning (RAL) exemplifies the transformative potential of AI and robotics in education. In this modality, robots serve as tutors, learning facilitators, or peer learners to engage students. These robotic systems are programmed to recognize student responses, adapt to individual learning paces, and provide feedback that can guide the educational process. RAL is particularly impactful in skill-based education, special education, and language learning, where the tactile and interactive elements of robots can enhance learning engagement and outcomes. Furthermore, it plays a significant role in preparing students for a future where human-robot collaboration is commonplace, ensuring they are adept at interfacing with advanced technologies.

These modalities illustrate the innovative ways in which the digital age is creating a more dynamic, customized, and inclusive educational landscape. As TVET institutions continue to explore and understand these modalities, it is crucial to ensure their implementation with a focus on equity and ethical considerations, guaranteeing that all learners benefit from technological advancements in education.

8.2.3 Teachers' roles from 'dual-professional' to 'multi-professional'

In the dynamic landscape of digital transformation, the professional role of TVET teachers is shifting from dual-professionals to multi-professionals. Traditionally, TVET educators were known for their blend of industry expertise and pedagogical skills. However, their competencies are now expanding to meet the emerging demands of the information age.

As Diao and Yang (2021) argue, a dual professional is not merely a teacher and a technician/engineer familiar with current practices in their field. They are also a digital citizen and a lifelong learner. This transformation is a response to the integration of new technologies that are reshaping teaching, learning, and work environments. As digital citizens, TVET teachers need to possess advanced information literacy, optimizing educational experiences in a digital environment by utilizing tools such as the IoT, big data, and AI to enhance vocational training. Moreover, as lifelong learners, they are expected to continually update their pedagogical knowledge, professional skills, and technical expertise to keep pace with rapid technological and industrial changes.

TVET teachers can assume several additional roles to address the multifaceted demands of evolving educational and industrial landscapes. These roles may include:

- **Technology Integrator**: This role involves researching, recommending, and assisting in the implementation of new technologies that enhance students' learning experiences, ensuring that TVET institutions remain at the forefront of pedagogical technologies. This includes, for example, the use of AI for personalized learning or predictive analytics, and the use of AI-assisted processes or machinery as part of technical training, ensuring that students gain hands-on experience with the technology relevant to their future industries.
- **Digital Resource Developer**: TVET teachers play a crucial role in creating, curating, and managing digital learning materials that align with vocational curricula and industry standards. This role encompasses the development of interactive e-learning modules, digital simulations, online courses, and multimedia resources that provide a blend of theoretical knowledge and practical skills.

- **Curriculum Innovator**: TVET teachers may participate in the design and ongoing refinement of curricula to ensure they reflect current industry standards, technological advancements, and methodological insights.
- **Industry Liaison**: By establishing robust connections with local businesses and industry leaders, TVET teachers can facilitate partnerships that benefit both students and industries, such as setting up internship opportunities or collaborating on practical projects.
- **Entrepreneurship Educator**: As entrepreneurship becomes an increasingly valuable skill, TVET teachers might also equip students with the knowledge and skills required to start and run their own businesses, fostering innovation and self-employment.
- **Community Engagement Specialist**: TVET teachers can also serve as a bridge between the educational institution and the community, creating programmes that provide community education and services and aligning training to local needs.

With the diversification of teaching and learning, the roles of TVET teachers have expanded. They must redefine their instructional abilities to integrate, reorganize, and adapt to evolving technological advancements, transcending traditional education boundaries to include industry and societal engagement. Therefore, the holistic professional development of TVET teachers is not only pivotal in facilitating a multifaceted pedagogical approach but also critical in nurturing a skilled, adaptable, and forward-looking workforce.

8.2.4 Focus on students' transversal skills and STEAM skills

A significant trend shaping the landscape of TVET amidst digital transformation is the growing focus on nurturing students' transversal skills in conjunction with Science, Technology, Engineering, Arts, and Mathematics (STEAM) competencies. This comprehensive educational approach acknowledges that while technical expertise is crucial, it needs to be supplemented by skills fostering adaptability and creativity. As automation and AI become increasingly prevalent, the capacity for critical thinking, complex problem solving, and engaging in creative and interdisciplinary thinking becomes indispensable.

Transversal skills, also referred to as soft skills or 21st-century skills, extend beyond domain-specific knowledge to encompass a range of abilities vital in the

contemporary workplace. These include critical thinking, empowering students to analyze and evaluate information from diverse sources; problem solving, involving the formulation of effective and innovative solutions to complex challenges; communication, essential for the clear and effective exchange of ideas; collaboration, facilitating productive teamwork; and digital literacy, a fundamental skill for navigating the progressively digitalized professional landscape. Such transversal competencies equip TVET students with the versatility and resilience needed to adapt to rapid technological changes. In the context of digital transformation, these skills are integral for workers to complement technology, adapt seamlessly to new paradigms, and continually advance their technical knowledge through self-directed learning in an ever-evolving digital economy.

STEAM education transcends the traditional boundaries of individual disciplines by integrating Science, Technology, Engineering, Arts, and Mathematics, promoting an interdisciplinary and applied approach. The 'Science' component fosters an understanding of natural phenomena; 'Technology' emphasizes the use of tools and machinery, including information technology; 'Engineering' introduces the design and construction of systems and structures; and 'Mathematics' instils logical reasoning and the ability to calculate and quantify. The inclusion of 'Arts' is crucial not merely for creativity but for stimulating innovative thinking, enabling learners to visualize and conceptualize ideas in unique ways. This amalgamation of skills is pivotal for the digital transformation in TVET as it marries the core technical abilities necessary for vocational proficiency with creative and critical thinking that drive innovation. As industries pivot towards high-tech, automation, and digital workflows, individuals skilled in STEAM are exceptionally positioned to lead the integration of new technologies into existing practices, ensuring the workforce is not only capable but also inventive and forward-thinking.

8.2.5 Micro-credential programmes

Micro-credentials are increasingly viewed as a transformative element in the future of TVET. As defined by UNESCO (2022, p. 20):

> A micro-credential:

- Is a record of focused learning achievement verifying what the learner knows, understands, or can do.
- Includes assessment based on clearly defined standards and is awarded by a trusted provider.
- Has standalone value and may also contribute to or complement other micro-credentials or macro-credentials, including through recognition of prior learning.
- Meets the standards required by relevant quality assurance.

The integration of micro-credentials into National Qualifications Frameworks (NQFs) can prevent the fragmentation of learning. However, this requires the recognition and trust of a list of micro-credential issuers. By utilizing micro-credentials, TVET providers can ensure their programmes remain relevant and facilitate a better alignment between the skills acquired through TVET and those demanded by the labour market.

Micro-credentials play a crucial role in enhancing the quality and efficiency of TVET. Research has shown that micro-credentials can promote the implementation of innovative models in education, specifically in TVET (Fisher & Leder, 2022; Tamoliune et al., 2022). These innovative strategies augment the variety of instructional methods, learning environments, and delivery approaches, catering to diverse learning needs and styles, particularly in technically oriented professions.

In terms of skills development, micro-credentials enable individuals to continually upgrade their skills and knowledge, aligning with the ethos of TVET to promote sustained professional development. Micro-credentials are inherently modular and specific, focusing on discrete skills and knowledge areas. This allows learners to articulate their abilities and qualifications to employers clearly. This specificity enhances the quality of TVET by directly addressing specific industry requirements and standards. Furthermore, micro-credentials offer flexibility in learning and support lifelong learning, a critical aspect in today's rapidly evolving industrial landscape. They allow for the easy updating and modification of curriculum components to keep pace with industry advancements, resulting in a more responsive and efficient TVET system.

Micro-credentials could also extend the influence of TVET beyond campuses, a shift that is particularly noticeable with the rise of online learning and blockchain technologies. As part of open-source resources, TVET courses coupled with micro-credentials can cater to a broad range of population learning needs. Consequently, the

beneficiaries of TVET will no longer be limited to registered students. Corporations offering micro-credentials and related training across national borders are leading the globalization of TVET institutions.

However, there are concerns that short courses focusing on narrow, pre-specified skills could limit the scope of the curriculum. Critics argue that micro-credentials might primarily enable professionals to gain visible certification for existing skills without supporting their acquisition (Kässi & Lehdonvirt, 2022). Moreover, the benefits of micro-credentials as part of the broader tertiary education system have not been sufficiently proven beyond specific sectors, and the sustainability of numerous MOOCs that award micro-credentials remains uncertain (UNESCO, 2023a). Therefore, the role of micro-credentials in TVET necessitates a careful balance, requiring continuous evaluation and refinement to harness their full potential while mitigating potential pitfalls.

8.2.6 International recognition of TVET qualifications

In response to the rapidly globalizing economy, efforts to facilitate the international recognition of skills qualifications in the field of TVET have increased. This trend recognizes the importance of establishing equivalence in skills and vocational qualifications across international borders.

Digital technologies enable efficient recording, assessment, and authentication of qualifications, irrespective of geographical origins. Electronic certificates and digital badges, which can be securely accessed and shared via online platforms, have become crucial. Unlike traditional paper-based certifications, these digital credentials can be easily stored, managed, displayed, and verified through digital wallets or repositories, making them readily available to educators, employers, and institutions worldwide.

Blockchain technology is another significant facilitator. Its decentralized ledger system provides an immutable record of qualifications that can be accessed globally, secure from fraud and tampering. This technology ensures that an individual's educational and professional achievements are accurately and securely recorded and that these records are internationally recognized and trusted.

Moreover, the standardization of qualifications facilitated by digital technologies is promoting mutual recognition. Organizations such as UNESCO and the European Centre for the Development of Vocational Training (CEDEFOP) utilize digital platforms to

establish equivalence across different countries' educational systems, providing a clear metric for comparing qualifications.

Digital portfolios, shared qualification frameworks, and international agreements are mechanisms likely to become more prevalent. These digital interventions represent a shift towards a more integrated global workforce and a step forward in addressing the challenge of disparities in educational and professional qualifications between nations.

8.2.7 Importance of lifelong, workplace learning

The workforce landscape is experiencing a significant shift due to increasing longevity and the rapid pace of technological change. As people extend their working years, there is a growing need for lifelong learning to ensure that workers can keep up with the latest advancements and maintain their relevance in the job market. This trend positions lifelong and workplace learning at the heart of digital transformation in TVET.

Lifelong learning encompasses the self-motivated pursuit of knowledge for personal or professional reasons. It is not limited to formal educational environments but includes a wide range of learning opportunities, from casual to structured settings, throughout an individual's life. The significance of lifelong learning lies in its ability to enhance individual adaptability, enrich personal development, and foster societal engagement. With the rapid pace of technological advancements and the dynamic nature of the global job market, maintaining a commitment to lifelong learning is crucial. It enables individuals to stay relevant in their careers, adapt to new job roles and technologies, and continuously engage with the evolving challenges of modern life.

Relatedly, workplace learning regards the acquisition of skills or knowledge within the employment context, directly enhancing employee performance and organizational productivity. It encompasses a spectrum of experiences, from formal training and professional development courses to less structured, continuous learning opportunities such as mentoring, on-the-job training, and collaborative projects. The importance of workplace learning has been amplified by rapid technological changes and the consequent need for upskilling. Companies are increasingly investing in learning and development programmes to ensure their workforce remains competitive and can utilize the latest tools and methodologies. Effective workplace learning strategies not only propel individual career progression but also bolster the organization's adaptability to market shifts, foster innovation, and maintain a robust talent pipeline ready to tackle future challenges.

8.3 Recommendations

To fully leverage the potential of digital transformation in TVET, it is essential to adopt a strategic approach that is both comprehensive and adaptable. This report concludes with a series of recommendations designed to enhance the digital capacities of TVET institutions. While these recommendations are primarily aimed at TVET institutional leaders and teachers, they also serve as useful references for policymakers and a wide range of stakeholders.

The recommendations are organized according to six key areas covered in Chapters 2–7, addressing the research question posed in Chapter 1: 'How can TVET institutions effectively plan and implement digital transformation to meet the evolving demands of the digital era?'

(1) Institutional strategic planning for digital transformation

- Adopt a continuous, iterative digital transformation process that responds to evolving technological landscapes and market demands, emphasizing systematic planning and flexible adaptation.
- Promote the development of a digital mindset, prioritizing digital literacy and adaptability, to ensure successful digital transformation at all organizational levels.
- Undertake a comprehensive and integrated digital transformation journey aligned with four strategic domains: educational and skills development, institutional capacity building, research and innovation, and industry collaboration and outreach.

(2) Digital transformation of TVET governance

- Develop TVET governance strategies that align with international, regional, and national guidelines to enhance the quality, accessibility, and flexibility of education through digital technology.
- Implement comprehensive and adaptable governance structures in TVET that integrate digital technologies, support innovation, and address digital transformation challenges in a rapidly evolving digital landscape.

- Engage a variety of stakeholders, including governments, educational institutions, and private sectors, in collaborative efforts for the successful and sustainable digital transformation of TVET.

(3) Digital transformation of TVET programmes and curricula

- Foster a collaborative multi-stakeholder ecosystem involving governments, industries, and other entities to ensure the alignment of TVET programme's skills supply with evolving market demands.
- Update and adapt TVET curricula to incorporate interdisciplinary skills, including digital literacy, to ensure students graduate with the versatile competencies necessary for the digitalized job market.
- Establish virtual training centres, online learning platforms, and digital databanks to enrich the learning experience, offering students practical, risk-free simulations and flexible, accessible educational pathways.
- Introduce or develop micro-credentials to enable students to follow flexible and personalized learning pathways, and to make TVET programmes more attractive and curricula more accessible.

(4) Digital transformation of EdTech and TVET pedagogy

- Build a secure, comprehensive digital infrastructure in TVET to facilitate a transformative, interactive, and intelligent educational ecosystem that equips the future workforce with adaptability and digital literacy.
- Incorporate emerging digital technologies into TVET to enable a globally accessible, interactive, and personalized learning environment that breaks traditional barriers of cost and geography.
- Implement a digital pedagogy in TVET that incorporates blended learning, VR/AR simulations, game-based learning, and flipped classrooms to create a more dynamic, personalized, and interactive educational experience.
- Integrate OERs in TVET to enhance global accessibility to educational materials, reduce costs, and foster collaboration and sustainability.

(5) Capacity building for TVET leaders, teachers, and students

- Enhance the digital competencies of TVET leaders to advocate for, plan, and support digital transformation. This focus should be on strategic vision, resource allocation, and fostering an environment conducive to innovation.
- Bolster the capacity of TVET teachers for digital transformation by enhancing their skills in utilizing digital tools and resources, integrating curricula, and adopting innovative pedagogical methods for online and blended learning.
- Cultivate digital competencies in TVET students, such as digital literacy and professional digital skills, in alignment with industry needs. This should promote practical technology use, critical thinking, and adaptability for lifelong learning.
- Implement a systematic approach to capacity building for digital transformation within TVET, focusing on leaders, teachers, and students. This will create an ecosystem that prepares graduates for a digitalized job market and propels the digital transformation of industries.

(6) International community engagement

- Fortify international cooperation in TVET by expanding engagement and information exchange among countries, regional groups, and a diverse array of educational and industrial stakeholders. This should foster alliances that facilitate shared solutions and innovation, tailored to geographical and cultural specificities.
- Advocate for innovative funding strategies for TVET digital initiatives by establishing collaborative financial models that unite public institutions and private industry contributions, ensuring the sustained advancement of TVET-related technology.

In conclusion, this report provides a framework to address digital transformation for TVET institutions, acknowledging limitations such as the dynamic nature of digital technologies, the diversity of global TVET systems, and potential resource constraints. The scope of this report's analysis may not cover all potential scenarios or emerging innovations in the field; thus, continuous observation and updates to our recommendations will be necessary. It is our hope that the global TVET community, including industry stakeholders, policymakers, and researchers, will build upon this work for further discussion and exploration. Embracing this digital transformation journey across TVET systems is crucial for building a resilient workforce equipped for future challenges and significantly contributing to global sustainable development.

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Appendix: Promising Practices

Area 1: Digital Transformation of TVET Governance

Case 1: Digitalization and partnership initiatives: catalysts for realizing 'Kenya Vision 2030'

In a united effort toward a prosperous future, the Kenyan government launched 'Kenya Vision 2030', an ambitious and comprehensive long-term development blueprint. Central to 'Kenya Vision 2030' is the aspiration to transform Kenya into 'a globally competitive and prosperous nation with a high quality of life by 2030'. This vision aims to transition Kenya into 'a newly-industrializing, middle-income country, ensuring a high quality of life for all its citizens within a clean and secure environment'.

To accelerate the realization of 'Kenya Vision 2030', the Kenyan government championed 'Digitalization' as a flagship project. Within this transformative framework, the Kenya School of Technical and Vocational Education and Training (KSTVET) was instituted as a government entity. Its primary mandate is to equip individuals with digital skills, thereby enabling them to contribute to technical institutions or excel in various economic sectors.

Committed to fostering a robust TVET ecosystem, KSTVET initiated the 'Digitalization and Partnership Programme'. This programme represents a collaborative endeavour with esteemed organizations such as UNESCO, Google, Intel, and Huawei. The main objective is to provide digital skills, including Android application development, to both young people and lifelong learners, thus promoting continuous growth in Kenya's dynamic tech industry.

Initially designed to address immediate teaching challenges amplified by the COVID-19 pandemic, the programme has evolved into a broader initiative tackling the difficulties faced by marginalized and remote communities in accessing quality training. These challenges include the lack of proximity to physical learning centres, associated costs, and cultural sensitivities.

In response to these challenges, KSTVET strategically implemented a series of interventions:

- **Flexible learning approach**: KSTVET adopted a flexible and blended learning methodology, integrating online and traditional classroom teaching seamlessly. This approach ensures a more adaptable learning environment for students. Universal design principles are applied to online content creation, accommodating diverse learning needs through various formats such as videos, audio, and text. The inclusion of built-in accessibility software further supports students with special needs.
- **Employability skills module**: KSTVET pioneered a fully digitized, self-paced 'employability skills' module, providing TVET students with a universally applicable unit of competence. This module enables students to learn at their own pace, supplemented by weekly online tutorials.
- **Supportive infrastructure and resources**: KSTVET established the National Open, Distance and eLearning platform, allowing TVET students to access learning materials and resources free of charge. In collaboration with Google, this platform is now accessible via mobile phones, significantly expanding its reach. To enhance the overall learning experience, KSTVET upgraded Internet bandwidth across all platforms. Additionally, a state-of-the-art virtual studio was developed, featuring eight 'virtual training booths' equipped with desktops, wall screens, Wacom interactive teaching boards, and phones for direct communication with trainers.
- **Enhancing trainer quality**: Leveraging its learning platform, KSTVET proactively improved the quality of training. Free courses were provided to TVET trainers nationwide, ensuring they possess advanced educational skills and knowledge.

This comprehensive case study aims to illuminate the crucial role of digitalization and collaborative initiatives in Kenya's unwavering pursuit of the 2030 vision. It highlights the challenges encountered during implementation and underscores the adaptive strategies adopted by KSTVET to overcome these hurdles, emphasizing the transformative impact on both educators and learners.

Source: https://unevoc.unesco.org/pub/digitalization_and_partnership_kenya.pdf

Case 2: 'Reform of TVET in Viet Nam': Empowering Vietnam's workforce through a holistic approach to digital transformation in TVET

In response to the global digital transformation, the Vietnamese Government acknowledges its importance in promoting advancements across government, society, and the economy. Influenced by factors such as the evolving nature of work, the Fourth Industrial Revolution (Industry 4.0), increased autonomy in education, and the challenges posed by the COVID-19 pandemic, there is a critical need for digital transformation in TVET. With only 26% of the workforce possessing professional qualifications and a predicted surge in demand for skilled workers, digital transformation in TVET is essential to enhance flexibility, openness, and responsiveness. The 'Reform of TVET in Viet Nam' programme has been developed as a strategic response to leverage the potential of digital transformation (DX) in addressing these challenges.

(1) Programme initiatives

- **Holistic DX ecosystem**: The programme, funded by the German Ministry for Economic Cooperation and Development (BMZ) and implemented by Deutsche Gesellschaft fuer Internationale Zusammenarbeit, adopts a comprehensive digital transformation ecosystem. This ecosystem comprises six interlinked components: training contents, digital teaching and learning methods, digital educators and students, digital infrastructure, administration, and the regulatory framework.
- **Stakeholder engagement**: Recognizing the importance of key stakeholders, the programme encourages active involvement from leaders, managers, staff, teachers, in-company trainers, students, and workers. This approach ensures a multifaceted engagement that spans TVET management organizations, colleges, enterprises, and professional associations.
- **Strategic support at multiple levels**: At the macro level, the programme supports the Directorate of Vocational Education and Training (DVET) and partner TVET colleges with strategic and policy advice, leveraging scientific research and fact-finding missions. Capacity development initiatives target senior leaders, line managers, and other stakeholders. At the meso level, the programme involves provincial authorities, Sector Skills Councils, Provincial TVET Councils, and industry associations. At the micro-level, direct advice is provided to partner

TVET institutes and enterprises for developing and implementing digital transformation strategies.

(2) Programme results

- **Research and policy initiatives**: Since September 2020, the programme has conducted fact-finding visits and a study on the status of digital transformation in TVET, receiving extensive responses from stakeholders. A policy review and a study on distance learning have been executed, contributing to evidence-based strategies.
- **Capacity development**: Various activities, such as workshops, training sessions, group discussions, and strategic meetings, have been organized. Intensive training workshops equipped 160 senior leaders, managers, and task forces. Practice-based training courses qualified core teachers and multipliers in OER and e-pedagogies. Workshops and discussions have raised awareness and digital literacy among over 1,800 managers, teachers, and staff.
- **Digital infrastructure and resources**: Partner TVET colleges have been supported with LMSs, digital management platforms, and cloud servers. The completion of DVET's OER platform and the establishment of modern virtual conference rooms and e-learning rooms facilitate the production of digital resources, technical exchange, and knowledge transfer.

(3) Conclusion

The 'Reform of TVET in Viet Nam' programme, through its strategic initiatives, has made significant strides in advancing Digital Transformation. From comprehensive research to capacity development and the establishment of digital infrastructure, the programme has laid the groundwork for a holistic approach to digital transformation in TVET. The involvement of key stakeholders at various levels ensures a comprehensive and sustainable transformation that aligns with the evolving needs of the workforce and the wider socioeconomic landscape. The programme serves as a testament to the potential of international collaboration and targeted interventions in shaping the future of TVET in Vietnam.

Source: https://www.tvet-vietnam.org/wp-content/uploads/2022/08/220623-NMC-Digital-Transformation-TVET-facsheet-FINAL-EN.pdf

Area 2: Digital Transformation of TVET Programmes and Curricula

Case 3: Innovative ICT education model between Shenzhen Polytechnic University and Huawei

Shenzhen Polytechnic University (SZPU), a distinguished TVET institution in China, has developed an innovative ICT education model. This model was created in collaboration with Huawei, a global leader in ICT solutions and products. The initiative, known as the 'Huawei Certification to ICT Programmes', was designed specifically to enhance the ICT skills of TVET teachers and students, preparing them as industry-ready professionals.

This model integrates Huawei's certification standards and courses into SZPU's existing TVET curricula. It provides extensive training and rigorous assessments for both students and teachers, thereby raising the standard of ICT education. Moreover, the model incorporates Huawei's enterprise certification into the TVET programmes, distinguishing it from traditional educational practices. This integration signifies an unprecedented private sector involvement in curriculum development, aligning education more closely with industry standards and requirements.

The approach utilizes various OERs and diverse training platforms to ensure comprehensive skill development of TVET students. It equips them with real-world challenges by exposing them to enterprise-level standards within their academic journey. The initiative's core principle is to enable students to gain practical experience and employable skills during their studies.

The partnership with Huawei has been beneficial for SZPU, enabling it to adapt to the rapidly evolving demands of the Chinese and global ICT industry. Huawei's insights into industry trends and identification of potential growth areas in qualifications and competencies have been invaluable for SZPU. Huawei's forward-thinking approach has assisted SZPU in preparing its students to be industry-ready.

The outcomes of this model have been exceptional. Over 5,000 students at SZPU, including 500 international students from 30 countries, have benefitted from this unique model. These students, equipped with their Huawei certificates, have secured well-paid roles in ICT-related fields. A testament to the success of this initiative is that SZPU students holding the Huawei Certificate of ICT Expert constitute the highest proportion of all university and college graduates globally with such a qualification.

The primary beneficiary of this model is the employability of TVET graduates. Their entrepreneurial prospects have significantly improved, and their credibility in the professional sphere has increased. Additionally, the reputation and recognition of SZPU have been notably enhanced by this practice.

In conclusion, the 'Huawei Certification to ICT Programmes', a collaborative effort between SZPU and Huawei, exemplifies effective public-private collaboration. The model has revolutionized ICT education in China and has proven to be a multifaceted success, setting a replicable benchmark for TVET institutions worldwide. It underscores the need for educators and industry leaders to collaborate in preparing students for the rapidly evolving professional landscape, while also equipping them with enterprise certification during their studies.

Source: UNESCO-UNEVOC. (2021). Huawei Certification to ICT Programmes. https://unevoc.unesco.org/bilt/Promising+Practices+in+TVET/lang=en/id=6557

Case 4: The 'Digital TVET Learning Platform' in Malaysia

In response to the COVID-19 pandemic, which disrupted traditional educational systems, Universiti Tun Hussein Onn Malaysia (UTHM) launched a unique initiative: the 'Digital TVET Learning Platform (DTLP)'. This digital transformation focused on TVET programmes, providing a means for learning to continue despite widespread lockdowns and movement restrictions.

With the onset of the pandemic, Malaysia's government imposed a stringent Movement Control Order, closing educational institutions and suspending conventional face-to-face learning. TVET programmes, known for their practical, hands-on training methodologies, were particularly affected. This situation signalled the need for new teaching and learning practices adapted to these unprecedented times.

To address these challenges, UTHM developed and launched the DTLP. The primary objective was to provide a virtual space where quality TVET education could continue unabated. The platform aimed to enhance teachers' skills and competencies for online instruction and foster an environment for knowledge sharing and exchange among its beneficiaries. As a result, the DTLP became an essential tool for educators, providing a space for the creation, access, and utilization of virtual realities, Open Educational Resources, and other digital learning materials.

The success of the DTLP lies in its tailored approach to meet the specific needs of TVET learners. Emphasizing active learning, teachers transitioned from traditional lecture-style teaching to facilitating self-led learning, thanks to the capabilities developed and offered through the DTLP. Participation and engagement were enhanced by regularly collecting stakeholders' feedback and incentivizing outstanding learning and development efforts. The platform's potential for broad application and replication by other TVET institutions was also highlighted, promoting holistic and adaptable education within this sector.

However, like any new venture, there were challenges. Participant motivation varied significantly, and issues related to Internet connectivity and a diverse range of digital foundation skills among the participants were observed. Nevertheless, UTHM managed these challenges effectively. They established personalized communication plans, conducted regular tutorial sessions, and rolled out incentives to keep participants motivated. Provisions were made to accommodate minimal Internet connectivity, and popular mobile communication platforms were utilized to foster support and

collaboration. Additionally, backup processes were put in place to safeguard against potential data loss through virus attacks and human errors.

Looking ahead, the DTLP holds immense potential. Its success during the pandemic underscores its viability as a sustainable learning ecosystem for the post-pandemic world. The programme's flexibility, focus on individual student needs, and seamless integration of digital technologies position it as an invaluable tool for future TVET education.

In conclusion, the DTLP, spearheaded by UTHM, is a shining example of educational resilience in the face of a significant global challenge. By equipping TVET teachers, trainers, and learners with vital digital skills and resources, learning continued during the most challenging times. The insights, lessons, and triumphs from this initiative hold the promise of shaping the future of TVET education in Malaysia and beyond.

Source: https://unevoc.unesco.org/pub/promising_practice_uthm.pdf

Area 3: Digital Transformation of EdTech and Pedagogy in TVET

Case 5: Enhancing TVET learning with virtual simulation: a transformative journey

In the dynamic field of TVET, innovation is pivotal in providing students with immersive and practical learning experiences. Shenzhen Polytechnic University (SZPU), in collaboration with Guangzhou Windmark Education Technology Co., Ltd., and Shenzhen EasyStar Company, has embarked on a pioneering initiative, adopting virtual simulation technology to transform practical training. This case study highlights the transformative journey sparked by PROTEUS virtual simulation instances, demonstrating how these innovative advancements are reshaping the educational paradigm.

(1) Tailoring learning experiences with PROTEUS virtual simulation

The collaboration between SZPU and Guangzhou Windmark Education Technology Co., Ltd. has led to the creation of PROTEUS virtual simulation instances. These are meticulously designed for a wide range of courses, including circuits, analogue electronics, digital electronics, and microcontrollers. This state-of-the-art technology enables students to undertake practical electronic circuit training from the comfort of their homes. Through virtual components and instruments integrated into their computers, students explore the complexities of electronic circuits. They simulate these circuits and measure virtual training data with precision, fostering a deep understanding of theoretical concepts translated into practical skills.

(2) Breaking temporal and spatial barriers: a leap into the digital realm

In a landmark collaboration with Shenzhen EasyStar Company, SZPU has transcended traditional boundaries of time and space, propelling student experiments into the digital sphere. By harnessing the potential of cloud-based infrastructure, students can now control laboratory hardware, allowing them to conduct experiments from anywhere with Internet connectivity. This innovative approach enables students to remotely manipulate intelligent experimental hardware platforms, facilitating real-time interaction with

physical circuits. Equipped with the ability to build, modify, and measure circuits, students navigate post-lab practical tasks with unprecedented ease and efficiency.

(3) Comprehensive practical training in the virtual realm: nurturing inquisitive minds

Virtual simulation technology provides a comprehensive solution, encompassing all aspects of practical training. From the careful selection of equipment to the adjustment of parameters, from the complex connections between chips to the precise measurements recorded by instruments, students actively participate in tasks meticulously orchestrated within the virtual realm. This hands-on approach not only fosters a deep and intuitive understanding of complex electronic concepts but also encourages students to undertake diverse and challenging electronic projects. These projects range from assembling and playing electronic keyboards to designing sophisticated parking lot counting displays, creating agile line-following robots, and engineering complex electronic clocks. The virtual simulation platform effectively addresses the limitations of traditional hands-on experiments, providing a nurturing environment for students to satisfy their curiosity and ignite their passion for knowledge.

(4) Educational impact and future prospects: paving the path ahead

The incorporation of PROTEUS virtual simulation instances has marked a transformative phase in TVET at SZPU. Students are now engaged in learning experiences that are not only interactive and intellectually stimulating but also fundamentally inclusive. By integrating virtual simulation technology into the curriculum seamlessly, the university has democratized access to high-quality practical training. This egalitarian approach ensures that every student, irrespective of their geographical location or physical presence, can participate in world-class technical education.

Looking ahead, the innovative collaboration between SZPU, Guangzhou Windmark Education Technology Co., Ltd., and Shenzhen EasyStar Company serves as a guiding light for the future of TVET. In an era of continuous technological advancement, the integration of virtual simulations into the educational framework is not just an option, but a necessity. The success story of SZPU stands as a model, underlining the immense potential of virtual simulation technology to enhance learning outcomes, overcome

geographical barriers, and inspire the next generation of skilled professionals in the ever-evolving field of TVET.

Source: https://gyzx.szpt.edu.cn/info/1104/1311.htm

Case 6: Work-based learning and skills demonstrations during COVID-19 in Finland by Omnia Education Partnerships

In March 2020, as the world faced the challenges of the COVID-19 pandemic, Omnia Education Partnerships (OEP) in Finland launched an initiative to ensure that TVET students could continue their courses and graduate despite the disruptions. OEP, the international consultancy and training arm of Omnia, a UNEVOC Centre in Finland, played a crucial role in addressing these challenges.

(1) Background

Finland's TVET system has consistently prioritized equal educational opportunities and vocational skill development, with an impressive 72% of secondary school students enrolled in TVET. However, the advent of COVID-19 presented a significant challenge, necessitating a transition to distance learning for TVET institutions and impacting work-based training sites.

(2) Key Players

OEP collaborated with TVET providers to address the pandemic's challenges. These providers, possessing a high degree of autonomy, were able to swiftly adapt to the new circumstances. The initiative also involved close collaboration with companies to tailor actions to the level of disruption.

(3) Problem Addressed

The primary issue was enabling TVET students to continue their education and graduate despite the disruptions caused by the pandemic. This necessitated the development of flexible solutions to ensure the continuation of WBL and skills demonstrations. The challenge extended beyond adapting to online learning to maintaining assessments and skills demonstrations in work-based settings.

(4) Implementation

The response to COVID-19 involved several key steps:

- **Flexible Learning:** TVET providers swiftly adapted to the pandemic, offering online training for students. Approximately 80% of students were able to continue their WBL in COVID-safe environments.
- **Adjusted Legislation:** A temporary amendment to Finnish legislation enabled TVET providers to arrange skills and competence demonstrations within the education provider's premises when work-based training was not feasible.
- **Online Learning:** Finland's pre-existing digitalization strategies facilitated the implementation of distance and online learning solutions.
- **Graduation Flexibility:** The legislative changes facilitated students' progress and timely graduation, with only 13% experiencing delays, typically of one to three months.

(5) Outcome

The initiative resulted in several positive outcomes:

- **Continued Learning:** The majority of students were able to continue their TVET studies despite the pandemic, with 71% of students expected to graduate on time.
- **Amended Legislation:** The temporary amendment to Finnish legislation allowed for greater flexibility and adaptation to the current situation.
- **Online Learning:** The promotion of digital skills and digitalization strategies facilitated a rapid transition to online learning.
- **Resilience:** The high degree of autonomy among Finland's TVET teachers supported flexible solutions in a crisis, enhancing the system's resilience.

The success of these measures suggests that the amended legislation and innovative learning and assessment models may become standard practice in Finland post-pandemic. Innovative assessment methods may become the norm, allowing for continued flexibility in TVET.

Finland's experience with the OEP-led initiative demonstrates the resilience and adaptability of its TVET system in the face of unprecedented challenges. Through collaboration, flexible adaptation, and a supportive legislative environment, they have not only overcome the hurdles posed by the COVID-19 pandemic but have also set a precedent for innovative approaches to TVET that will shape the future of education in Finland and beyond.

Source: https://unevoc.unesco.org/pub/promising_practice_oep.pdf

Area 4: Capacity Building for Digital Transformation in TVET

Case 7: The UNESCO-UNEVOC TVET Leadership Programme

The UNESCO-UNEVOC TVET Leadership Programme is designed to enhance the capabilities of TVET leaders globally, enabling them to become effective change agents within their institutions and beyond. The Programme's goal is to update participants' understanding of the latest TVET developments and provide them with the necessary skills and tools for effective leadership in the sector. Since its inception in 2016, the Programme has successfully trained over 700 TVET leaders, managers, and staff from more than 95 countries through both in-person and online editions.

This Programme comprises three key dimensions for TVET leaders to become change agents: strategic knowledge, thematic knowledge, and leadership and management skills. Among these, significant emphasis is placed on the digital transformation of TVET. The dedicated module on digital transformation provides senior TVET professionals with the knowledge, skills, and tools required to integrate digital technologies into TVET and the skills development system. It underscores the importance of keeping abreast of emerging EdTech trends, thereby enabling leaders to formulate digitally-enhanced policies and programmes that equip graduates for success in a rapidly evolving digital landscape. This session is designed to prepare TVET professionals to navigate and leverage the digital revolution in education and workforce development.

In 2021, the Programme marked a significant milestone in adapting TVET to meet the challenges of the digital age, particularly under the acute pressures of the COVID-19 pandemic. The event was delivered entirely online, a departure from the traditional face-to-face setting at the UNESCO-UNEVOC International Centre in Bonn, Germany, due to pandemic-related constraints. The first batch, which commenced on 7th September under the theme 'Skills for The Digital Transformation: How TVET Institutions Can Respond to Future Demands', included 31 leaders and managers from 25 different countries and across 16 UNEVOC Centres. Despite the emphasis on digital interactivity, it retained the key features of peer learning and knowledge exchange, which have always been the backbone of the programme.

The second batch in November 2021 continued with an in-depth exploration of digital demands and responses, targeting another 30 TVET leaders and managers from 24

countries and 12 UNEVOC Centres. The curriculum across both batches underscored the dual nature of digitalization—its disruptive aspect and its capacity to enable innovative, flexible learning solutions. Leaders and managers were exposed to cutting-edge labour market trends, transformative case studies, strategic mastery for institutional fortification, and foresight planning. The Programme's rich content was designed to stimulate transformative thought, equipping leaders to guide their institutions towards sustainable growth and resilience.

Overall, the central objective was to equip participating leaders with the skills to strategize robust support systems within their institutions, tailoring them to the intricacies of the digital era. This involves deciphering the complex relationship between the economic shifts induced by the pandemic and the burgeoning digital skill requirements. All these aspects are closely linked to the Programme's core mission: to empower and uplift leaders within the TVET sphere. It provides them with critical skills and knowledge to effectively navigate the multifaceted and ever-evolving landscape of digital transformation. Consequently, this ensures that their institutions are not just current but at the forefront of the global labour market's demands.

Source: https://unevoc.unesco.org/home/Launch+of+the+2021+UNESCO-UNEVOC+TVET+Leadership+Programme

Case 8: UNESCO-China Funds-in-Trust Project Phase III: Higher technical education in Africa for a technical and innovative workforce

The 'UNESCO-China Funds-in-Trust (CFIT) Phase III: Higher Technical Education in Africa for a Technical and Innovative Workforce' project was initiated through an agreement signed by the People's Republic of China and UNESCO in October 2019. This project focuses on capacity building of higher education institutions (HEIs) , promoting collaboration between higher education and industry, enhancing teaching methods to align with labour market demands, and facilitating competency-based learning. CFIT Phase III is being implemented in six countries: Côte d'Ivoire, Ethiopia, Gabon, Senegal, the United Republic of Tanzania, and Uganda, with an intended duration of four years, concluding in 2025.

The CFIT project aims to enhance the capacity of teachers involved in higher technical education to better facilitate skills delivery for national development. It directly benefits HEIs and graduate students enrolled in higher technical education programmes. The project's specific objectives are to:

- Enhance the delivery of technical education by effectively using information from labour market analysis, curriculum review, and graduate tracer studies;
- Lead to improvements in the quality and relevance of the curriculum and programmes offered by HEIs, ensuring they meet the demands of the labour market, promote inclusiveness, and promote gender equality;
- Adopt improved assessment methods that focus on developing competence-based training;
- Strengthen cooperation between HEIs and private sector stakeholders, crucial to labour market analysis, curriculum review, provision of work-based training opportunities, programme development, assessment reform, and the delivery of technical higher education.

The project adopted eight actions to support teachers in higher technical education in Africa. These actions include conducting a job market analysis and using the findings to refine higher technical education, critically reviewing current curricula and programmes to better align training with job market needs, and conducting graduate tracer studies to provide insights for technical education delivery. The project also supports teachers in transforming curriculum and introducing new training programmes to enhance

their relevance to the job market, enhances teacher capacity to deliver curriculum in higher technical education, and develops and validates a competency-based assessment framework for teachers. Furthermore, it guides teachers to provide WBL opportunities for graduates to develop their professional skills and competencies through partnerships with private sector enterprises and advocates partnerships with relevant private sector stakeholders to inform decision-making about the improvement of higher technical education.

The CFIT III Project has yielded significant achievements. It developed the Guidelines for the Establishment of Industrial Advisory Committee(s), and the Handbook on Competence-Based Assessment Methods for University Instructors, Tutors, and Teachers, which supported teachers in programme and curriculum design. It mobilized key stakeholders in higher technical education and built partnerships between technical education institutions and the private sector to provide WBL through internships and apprenticeships. It also produced research results from labour market analysis and identified skills gaps to guide the establishment or revision of curricula. Overall, this project improved the teacher capacity for curriculum development in two higher technical education institutions in each participating African country.

Source: https://www.unesco.org/en/articles/china-funds-trust-phase-iii-cfit-iii-higher-education

Area 5: International Collaboration and Exchange in the Digital Transformation of TVET

Case 9: UNEVOC Network Coaction Initiative 2023 at SZPU: Capacity Building on Digital Transformation in TVET

The UNEVOC Network Coaction Initiative, a comprehensive project launched by UNESCO-UNEVOC, is designed to assist UNEVOC Centres in the development and implementation of collaborative projects centred on mutual interests. UNEVOC Centres are invited to submit project proposals for a rigorous selection process, focusing on thematic areas that align with the UNESCO-UNEVOC Medium-Term Strategy (2021-2023) and the UNESCO Strategy for TVET (2022–2029). These areas encompass:

- Support for TVET staff in a digital world,
- TVET for climate action (including Greening TVET),
- Inclusive TVET (including entrepreneurship for disadvantaged youth and gender equality in TVET),
- Private sector engagement in TVET, and
- Enhancement of TVET institutions' responsiveness in the post-COVID-19 era.

A notable project initiated under the UNEVOC Network Coaction Initiative is the 2023 programme, 'Capacity Building on Digital Transformation in TVET'. Spearheaded by the UNEVOC Centre at Shenzhen Polytechnic University (SZPU) in China, the programme aims to equip at least 60 key leaders, programme directors, teachers, and trainers from six UNEVOC Centres across the Asia-Pacific region. The objective is to foster and augment their digital mindset and skills, thereby facilitating systematic digital transformation within their respective UNEVOC Centres. This initiative is anticipated to bridge the global digital skills gap, making a significant contribution to the wider framework of global sustainable development.

Selected to participate in this programme were partner centres from diverse locations in the Asia-Pacific region, including the National Skills University Islamabad (NSU) in Pakistan, Preah Kossomak Polytechnic Institute (PPI) in Cambodia, Temasek Polytechnic (TP) in Singapore, Universiti Tun Hussein Onn Malaysia (UTHM) in Malaysia, and the Zhejiang Technical Institute of Economics (ZJTIE) in China.

Throughout the programme, participants were expected to actively engage in numerous webinars, encompassing a range of topics. These included digital transformation theory

and methodologies, the evolution and transformation of TVET programmes and curricula, digital education techniques, digital pedagogies, and OERs. The series culminated in the sharing of promising practices and a wrap-up session.

A distinctive feature of the programme was its focus on institutional-level tasks. Each webinar incorporated group discussions, promoting critical thinking and active participation. Institutions were urged to nominate leaders or moderators to steer these discussions and compile outcomes for future use. The 'Learning-Sharing' tasks, where discussion outcomes were shared in subsequent webinars, facilitated follow-up. This approach fostered a productive cycle of knowledge exchange and dissemination.

The programme concluded with each institution submitting their promising practices. This compilation of innovative approaches and solutions in the field of TVET will serve as a valuable reference for future initiatives, effectively promoting a networked approach to innovation and dissemination. This dynamic exchange of ideas encapsulates the overarching goal of the UNEVOC Network Coaction Initiative 2023: to equip leaders and educators in TVET sectors with the necessary skills to navigate and lead the digital transformation of the future.

Source: https://unescoplatforms.szpt.edu.cn/info/1010/1649.htm

Case 10: Connecting Education 2030: UNESCO Bangkok's ICT in Education Programme

UNESCO Bangkok's ICT in Education Programme, spanning over 48 member states in the Asia-Pacific region, addresses diverse educational needs and challenges. As a focal point in the region, UNESCO Bangkok initiates measures to bridge digital divides and facilitate cooperation among multiple stakeholders for digital competency development.

The programme's central mission is to harness the power of ICT to foster accessible, efficient, and inclusive education, aligning with the goals of Education 2030. To maximize effectiveness, the Asia Pacific Regional Strategy on Using ICT is implemented, addressing four primary priority areas to achieve the Education 2030 targets. The first area focuses on secondary education, TVET, and higher education. Recognizing the undeniable role of ICT in enhancing quality education, this programme seeks to broaden access to high-quality education and enrich learning experiences for students at various educational stages. The implementation could range from creating online educational resources to developing digital platforms for student-teacher interaction.

The second area emphasizes improving the quality of teaching and teaching practices. Given that teachers are the backbone of any education system, enhancing their effectiveness directly influences the quality of education. The integration of ICT in teaching methods can create more engaging learning environments, thereby elevating educational standards. Additionally, it provides opportunities for teachers' professional growth, enabling them to adapt to the evolving dynamics of education.

The programme also prioritizes fostering inclusion and equality. Every learner, irrespective of their background, should have equal opportunities to access quality education. The implications of a digital divide are addressed by promoting a more inclusive education system through ICT. This approach involves producing educational resources and strategies that cater to the diverse needs of learners in the region.

Lastly, the programme underscores the importance of monitoring and evaluation to ascertain the effectiveness of ICT incorporation in education systems. A robust evaluation system allows for the identification of areas for improvement, ensuring a regularly updated system that operates most efficiently. By evaluating the impact of ICT initiatives, member states can make informed decisions to enhance educational outcomes based on solid evidence.

In the course of implementing various projects, publications, and events, member states accumulate knowledge, resources, and support to utilize ICT effectively for educational purposes. The power of collective action is harnessed by uniting stakeholders from government, educational institutions, civil society, and the private sector. This collaborative effort is a crucial step in advancing digital competency development in the region.

In conclusion, UNESCO Bangkok's ICT in Education programme plays a pivotal role in assisting member states in utilizing ICT to meet the targets of Education 2030. By focusing on key areas such as secondary and higher education, quality of teaching, inclusion, and effective monitoring, this programme strives to improve educational outcomes and promote equitable education across the Asia-Pacific region. The shared knowledge and cooperation fostered through the programme's initiatives contribute to the progression towards a digitally competent society.

Source: https://bangkok.unesco.org/index.php/content/unesco-regional-meeting-bridging-digital-divides-multi-stakeholder-cooperation-educators-youth-competency