unesco

Enhancing TVET through digital transformation in developing countries

Education 2030

UNESCO – a global leader in education

Education is UNESCO's top priority because it is a basic human right and the foundation for peace and sustainable development. UNESCO is the United Nations' specialized agency for education, providing global and regional leadership to drive progress, strengthening the resilience and capacity of national systems to serve all learners. UNESCO also leads efforts to respond to contemporary global challenges through transformative learning, with special focus on gender equality and Africa across all actions.

The Global Education 2030 Agenda

UNESCO, as the United Nations' specialized agency for education, is entrusted to lead and coordinate the Education 2030 Agenda, which is part of a global movement to eradicate poverty through 17 Sustainable Development Goals by 2030. Education, essential to achieve all of these goals, has its own dedicated Goal 4, which aims to ***"ensure inclusive and equitable quality education and promote lifelong learning opportunities for all."*** The Education 2030 Framework for Action provides guidance for the implementation of this ambitious goal and commitments.

unesco

United Nations
Educational, Scientific
and Cultural Organization

Education 2030

Published in 2023 by the United Nations Educational, Scientific and Cultural Organization,
7, place de Fontenoy, 75352 Paris 07 SP, France

Cover photo: fizkes/Shutterstock.com

Inside icons:
p.9: Rufat Bunyadzada/Shutterstock.com; RaulAlmu/Shutterstock.com; Phumsky/Shutterstock.com; M-vector/Shutterstock.com
pp. 14-15: Rvector/Shutterstock.com; ANTSTUDIO/Shutterstock.com; DStarky/Shutterstock.com; Iconography - Videography/Shutterstock.com

Designed and printed by UNESCO

Printed in France

ED/PLS/YLS/2023/02

Acknowledgements

This document was produced with the financial support of the Federal Ministry for Economic Cooperation and Development (BMZ) and the technical support of Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, provided by Jeanette Burmester, Hannah Petersen, Carole Benda and Julia Himstedt. Overall guidance on its production was provided by Borhene Chakroun, Director of the Policies and Lifelong Learning Systems Division, and Hervé Huot-Marchand, Chief of the Section for Youth, Literacy and Skills Development of the United Nations Educational, Scientific and Cultural Organization (UNESCO).

This document was written by Alan Amory, Deborah Hunt, James Keevy, Patrick Molokwane, Lungelo Mthembu-Salter, Andrew Paterson, Carla Pereira, Kelly Shiohira and Tanya Kapoor, with support from Mark Forsberg. Danilo Leite Dalmon and Hiromichi Katayama (UNESCO) provided direction and supervision throughout the production of this report.

The authors would like to thank the various country representatives from Brazil, India, Jamaica, Kenya and Tunisia who freely gave their time and shared insights. This research would not have been possible without their contribution.

The following reviewers also provided valuable contributions: Alessandro Brolpito (European Training Foundation [ETF]); Sarah Elson-Rogers (UNESCO-UNEVOC); Frances Ferreira (Commonwealth of Learning [COL]); Outi Katariina Kärkkäinen (UNESCO/ETF); Claudia Pompa (UNESCO); and Roy Saurabh (UNESCO).

Beatriz Goncalves Salgado (UNESCO) coordinated the production and publication process. UNESCO-UNEVOC International Centre supported the dissemination of this document. Romy de Courtay edited this report.

Table of contents

Table of contents

List of figures

List of tables

Acronyms

ACQF	African Continental Qualifications Framework
AI	Artificial intelligence
AR	Augmented reality
ANETI	Agence Nationale pour l'Emploi et le Travail Indépendant (Tunisia)
ATFP	Agence Tunisienne de la Formation Professionnelle (Tunisia)
CAD	Computer-aided design
CARICOM	Caribbean Community
CBET	Competency-based education and training
CEDEFOP	European Centre for the Development of Vocational Training
CENAFFIF	National Centre for Instructor Training and Training Methodology (Tunisia)
CNFCPP	Centre National de Formation Continue et de Promotion Professionnelle (Tunisia)
COL	Commonwealth of Learning
CPD	Continuing professional development
DDU-GKY	Dayal Upadhyaya Grameen Kaushalya Yojana (India)
DGBL	Digital game-based learning
DTC	Digital Transformation Collaborative
EAC	East African Community
ETF	European Training Foundation
ETF	European Training Foundation
HEART/NSTA	Human Employment and Resource Training Trust/National Service Training Agency Trust (Jamaica)
GEC	Global Education Coalition
GoI	Government of India
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GSA	Global Skills Academy
GSMA	GSM Association
HEI	Higher education institution
ICT	Information and communications technology
ILO	International Labour Organization
ITU	International Telecommunication Union
KNLRD	Kenya National Learners' Records Database
KNQA	Kenya National Qualifications Authority
LMIC	Low- and middle-income country
LMS	Learning management system
MENA	Middle East and North Africa
MFPE	Ministère de la Formation Professionnelle et de l'Emploi (Tunisia)
MOOC	Massive open online course
MoRD	Ministry of Rural Development (India)
MSDE	Ministry of Skill Development and Entrepreneurship (India)
NAQIMS	National Qualifications Information Management System (Kenya)

NSDC	National Skill Development Corporation (India)
NSQF	National Skills Qualification Framework (India)
PCK	Pedagogical content knowledge
PMNAM	Pradhan Mantri National Apprenticeship Mela (India)
QAI	Qualification Awarding Institutions (Kenya)
SENAI	Serviço Nacional de Aprendizagem Industrial (Brazil)
SID	Skill India Digital
SVEP	Start-Up Village Entrepreneurship Programme (India)
TVET	Technical and Vocational Education and Training
TVETA	Technical and Vocational Education and Training Authority
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNEVOC	UNESCO International Centre for Technical and Vocational Education and Training
VET	Vocational education and training

Glossary of terms

Credential fluency	The increasingly seamless interrelationships between the recognition of formal, non-formal and informal lifelong learning made possible through a user-centric approach, digital forms of recognition, improved data interoperability, and closer alignment between learning and the world of work. https://unesdoc.unesco.org/ark:/48223/pf0000381494
Data ecosystem	The complex web of organizations and individuals which directly and indirectly consume, generate, share and process data and related resources, including software, services and infrastructure. https://doi.org/10.1145/3209281.3209335
Datafication	The process of quantifying elements of human life into forms of digital information so that they can be measured, tabulated and analysed, and used as a continuous source of data. https://policyreview.info/concepts/datafication
Digital transformation in TVET	The planned and structured introduction of technology into institutions and national TVET systems with the goal of enhancing scope, scale, efficiency, effectiveness and ultimately, ensuring more sustainable development.[1] Source: Authors
Digital platforms	A software-based online infrastructure that facilitates interactions and transactions between users. https://doi.org/10.1057/s41265-016-0033-3
Digitalization	The practice of utilizing technology to enhance corporate processes. https://theecmconsultant.com/digitization-vs-digitalization/
Digitization	The process of converting analogue information into a digital format. https://www.gartner.com/en/information-technology/glossary/digitization
Digital credential	A digital record of focused learning achievements, verifying what the learner knows, understands and/or can do. https://europa.eu/europass/en/what-are-digital-credentials
Digital pedagogy	How best to use existing, new and emergent digital technologies in teaching and learning. https://www.jisc.ac.uk/full-guide/digital-pedagogy-toolkit
Digital skills	The skills required to use digital technology in daily life. These skills are best understood on a graduated continuum from basic functional skills to higher-level, specialist skills and include 'a combination of behaviours, expertise, know-how, work habits, character traits, dispositions and critical understandings.' https://unesdoc.unesco.org/ark:/48223/pf0000259013
Interoperability	'[T]he ability of discrete computer systems or software to exchange and make meaningful use of shared data or other resources.' https://www.jet.org.za/resources/interoperable-data-ecosystems.pdf
Massive open online course (MOOC)	'Online courses designed for a large number of participants that can be accessed by anyone anywhere, as long as they have an internet connection.' https://publications.jrc.ec.europa.eu/repository/handle/JRC96968
Open data	Data that can be freely used, re-used and distributed without restriction. https://opendefinition.org/
Open educational resources	'[T]eaching, learning and research materials in any medium - digital or otherwise - that reside in the public domain or have been released under an open licence that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions.' https://unesdoc.unesco.org/ark:/48223/pf0000246687?posInSet=1&queryId=10fe2a4e-db8c-4213-94d5-c05deb855ec9

1. Digital transformation in TVET aims for learners to have the skills and competencies necessary to contribute to a digital economy and society. These skills and competencies should provide individuals with more opportunities and, in the aggregate, accelerate progress towards reaching sustainable economic and social development goals.

Executive summary

Technological advancements and digitalization are profoundly reshaping our work and lifestyle, business models and operations, and government policy choices. While these advancements have brought strong economic dividends and efficiency and productivity gains in a wide range of areas, from agriculture to health, infrastructure, environment and education (see International Labour Organization [ILO], 2021b; UNESCO, 2018; World Bank, 2016), digital transformation's uneven expansion across countries can lead to unequal employment effects across areas at different stages of development and technology adoption, creating digital divides within and between countries (ILO, 2021a; UNESCO, 2022b). In the absence of proactive policies, the digital technological gap between the most advanced and the least advanced countries is likely to grow.

In addition, most experts agree that activities with the highest automation potential – and hence the highest potential to become redundant – are routine-based jobs with predictable physical activities that are concentrated in developing countries, mostly among informal workers, women and migrant workers (ILO, 2021d). This means that LMICs will disproportionately bear the burden of adjusting employment to technological disruption (Carbonero et al., 2018). Moreover, employees working in the most exposed roles are the least likely to receive any on-the-job training, or even to have any prior formal education (Nedelkoska and Quintini, 2018). Thus, even if digitalization creates new work opportunities, specific skill-transition policies will be necessary to mitigate inequality in accessing those opportunities.

The increasing use of digital technologies (especially after the COVID pandemic) is also driving change in the tools and modalities of learning, assessment and certification, along with career guidance, job matching and labour-market services (ILO, 2021c). In this context, TVET and skills systems across the globe must respond to the external demand for new skills from our increasingly digital society and enterprises. As they do so – and much like any other sector – they themselves must engage in digital transformation and respond to the challenges it presents to their institutions, staff and learners (ILO, 2021c). The design and implementation of TVET policies, the forecasting of supply and demand for skilled workers, and the updating of TVET certification systems, curriculum design and delivery are all greatly influenced by the digital transformation of TVET, which this document refers to throughout as digital transformation in TVET.

> Overcoming challenges posed by rapid global technological developments, worldwide increases in youth unemployment and the growing demand for green skills are key imperatives for the education and skill-development sector if the goals in the 2020 Agenda for Sustainable Development and the Education 2030 Agenda are to be realized. To achieve these goals, as promoted by the UNESCO 2022–2029 Strategy for TVET, teaching institutions have three key priorities: develop skills for all individuals to learn, work and live; develop skills for inclusive and sustainable economies; and develop skills for inclusive and peaceful societies.

This document contributes to these important discussions by exploring the context, trends and challenges inherent to digital transformation in TVET in different LMICs, focusing on national policy-makers and regional or institutional practitioners. The main research question of the study is as follows: 'How can TVET systems be enhanced through digital transformation in TVET in low- and middle-income countries?'

The research was conducted over a four-month period, ending in early 2023. It comprised an initial exploratory literature review to provide a basis for the case studies and conceptual framing, followed by a set of five LMIC country case studies (Brazil, India, Jamaica, Kenya and Tunisia), selected to provide broad insights into digital transformation in TVET in TVET in the following areas:

Digital transformation in TVET

Digital transformation is a complex process that with varying impacts across economic sectors. In the education and training sector, digital transformation in TVET can involve TVET operational systems (administration, finance, human resources, building infrastructure and maintenance, student registration, etc.); classroom delivery (learning management, instructional delivery methods, etc.); and the actual knowledge and skill component of the curriculum, for example by integrating productivity software such as word processors or spreadsheets into students' learning outcomes. The integration of digital skills in the TVET curriculum allows learners to acquire the changing skills and knowledge (tacit and explicit) required to function in a digitalizing society, economy and labour market. Digital transformation in TVET is also transforming the dominant modalities of traditional face-to-face learning and teaching to involve multiple configurations of actors (learners, teachers and technologies/apps) in space and time (when, where, who, how). This means that digital transformation in TVET offers opportunities for teachers to reconsider their pedagogical assumptions, behaviours and relationships with students.

Digital transformation in TVET can probably be best understood as a complex evolutionary process (see ILO, 2021a). It starts with converting and organizing information into digital data. It then progresses through automation and the use of technology to 'streamline processes'. It culminates in *digital transformation*, 'where a whole-of system digitalization strategy' impacts the entire system, from the individual TVET institution all the way to the overarching level of the national skill system.[2] Only when this final transformative stage is achieved can a degree of interoperability be enacted as information from multiple sources is combined to provide innovative actionable insights for stakeholders at all system levels (not only bottom-up), resulting in widespread and ubiquitous practices.

This study defines digital transformation in TVET as follows:

- Digital transformation in TVET is the planned and structured introduction of technology into TVET institutions and national TVET systems through digital technology, with the goal of enhancing scope, scale, efficiency, effectiveness and ultimately, contributing to more sustainable development.

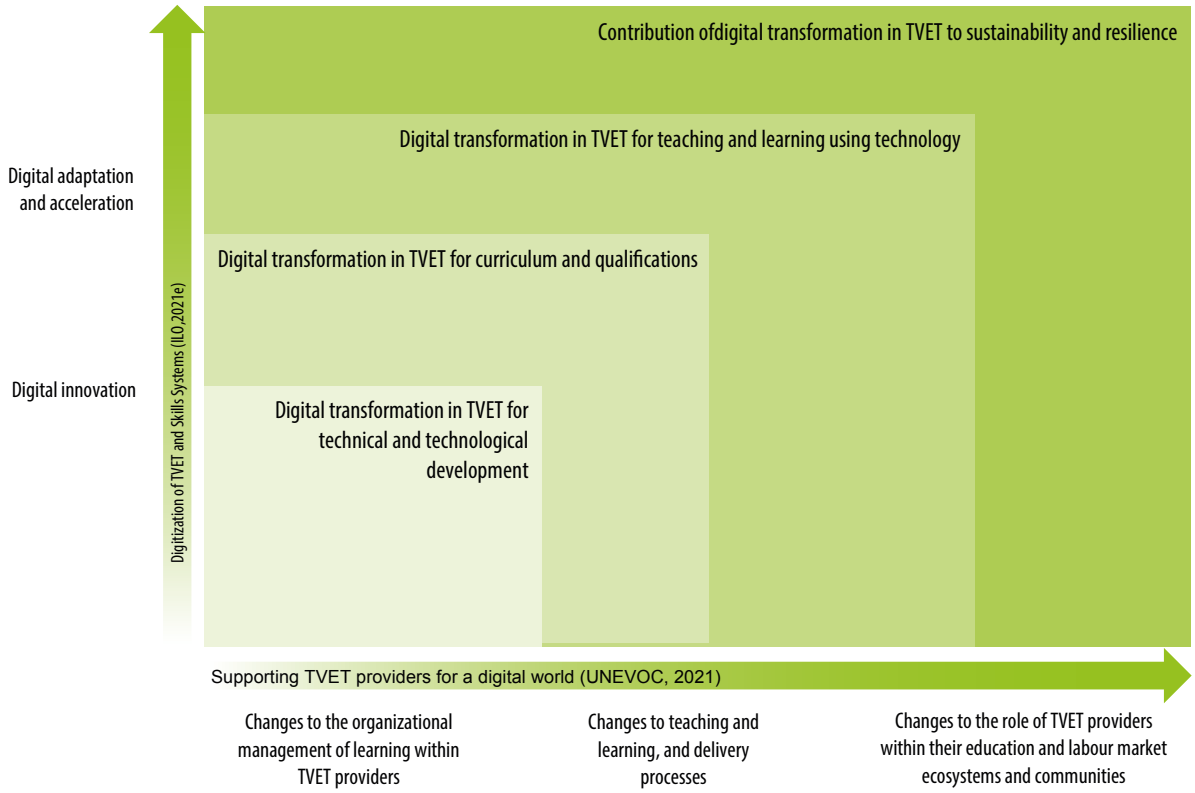
For TVET institutions, this means ensuring that learners have the skills and competencies necessary to contribute to the digital economy and society, resulting in more opportunities and driving progress towards the realization of the Sustainable Development Goals (SDGs).

A conceptual framework for digital transformation in TVET was developed for this study, building on two recent studies by the ILO (2021b) and UNEVOC (n.d.), and considering the most recent work of the Global Education Coalition (GEC) on a Digital Transformation Collaborative (DTC) (UNESCO, 2023c). In Table 1, digital transformation in TVET can occur across four levels of increased sophistication: technical and technological; curriculum and qualifications; teaching and learning using technology, which includes both pedagogy and instructional platforms and tools; and the contribution of digital transformation in TVET to sustainability and resilience.

The conceptual framework provided the study with a pragmatic lens through which to explore existing practices in LMICs, with a view to drawing out best practices and lessons learned from practitioners at both the governance level and on the ground. Desktop research and country case studies conducted to better understand existing practices and trends in digital transformation in TVET in LMICs; how TVET stakeholders in LMICs can improve their TVET systems and skill development, including lifelong learning opportunities, through digital transformation in TVET; how TVET practitioners introduce digital transformation in TVET concepts into learning and teaching, including lessons learned; and the effects of digital transformation in TVET on teachers and students, including the latter's learning outcomes and entry into the world of work. The five country case studies were selected based on their geographical locations and coverage of the four levels of the conceptual framework, as illustrated below.

2. https://unevoc.unesco.org/home/Digital+Transformation+in+TVET

Table 1. Conceptual framework for digital transformation in TVET



Source: Authors.

The digital transformation in TVET in TVET examples presented in the five LMIC case studies show good efforts towards digital transformation in TVET. However, in the chain of digital development, these countries are still primarily focusing on the early stages of digitizing information and providing access to and through technology, emphasizing connectivity and devices, blended learning models and more flexible learning opportunities, and integrating MOOCs and/or industry credentials within current curricula. The work in the middle, where efficiency and effectiveness have the potential to be improved dramatically, is still mostly nascent –– even in these LMICs, which are considered as advanced cases. The first efforts countries seem to make at this middle level focus on using learning management systems (LMS) to gather student data for more informed teacher practice (in theory, and with many caveats). At the level of digital transformation, where new insights might be generated, early efforts from leading LMICs focus on aggregating labour-market data and education data to gain insights on skill-matching.

The case-study countries have managed digital transformation in TVET in varying ways to achieve different imperatives, driven by their own circumstances and contexts. However, there exist several cross-cutting findings, which are especially relevant for other LMICs wishing to promote digital transformation in TVET.

Enabling factors for digital transformation in TVET

While not a comprehensive list of all possible enabling factors in every context, the following four enabling factors for digital transformation in TVET in the context of LMICs have emerged from this study:

a. Ensure a level of digital infrastructure that can support digital transformation in TVET at a level and pace appropriate to the country: Private-sector innovation can be relied upon to some extent, but enabling policies, advocacy, targeted interventions for the most marginalized and relevant training for citizens are important initiatives in this regard.

b. Place equality and inclusivity at the core of digital transformation in TVET: Ultimately, digital transformation in TVET must contribute towards ensuring the country's sustainability and resilience. Its strongest contribution is in creating equal opportunities for larger groups of citizens to gain competencies relevant to this goal.

c. Follow a coordinated approach between institutional transformation and the acquisition of new digital skills by practitioners, managers and policy-makers.

d. Develop enabling legislation that leverages digital transformation in TVET to strengthen TVET policies, including on data privacy, and new skill-recognition systems facilitated by increased data interoperability.

Digital transformation in TVET for technical and technological development

At the national level, all countries reported an increased investment in technology. Examples from the case studies included the installation of an optical fibre cable linking Tunisia with Europe, the 'Digital India' digitization drive and the 'Digital Bangladesh' initiative.

Every case study identified systemic (and mostly inhibiting) factors within education and training systems that influence digital transformation in TVET:

a. Poor access of the population to devices: While major goals centre on equity, case-study participants recognized that not all people in society will have access to devices. They expressed the sentiment that TVET institutions cannot take on this burden, and looked to personal investments or national initiatives to provide access to the necessary devices.

b. Lack of access to, and/or the high cost of, connectivity: Participants suggested that corporate innovations could promote access to affordable connectivity, together with public-private partnership (PPP) initiatives, such as telecommunications companies zero-rating education-related websites. Although not zero-rated, the 'Digital India' example shows that offering cheap, 4G-only high-speed mobile data using a spectrum suited to both voice and data as part of an aggressive government-championed PPP is a viable, effective and cost-effective solution that can work well in developing countries. However, not all developing countries possess the necessary infrastructure, which requires substantial investment.

c. The availability of information online does not equate the ability to access this information. This is particularly evidenced in the Kenyan case study.

d. A key challenge for digital transformation in TVET is to integrate technology and data with existing systems and databases. To some extent, India and Brazil have been able to aggregate labour-market and education data to gain insights on skill-matching.

Digital transformation in TVET for curriculum and qualifications

International TVET systems have been strongly influenced by CBET approaches to curriculum design and assessment. Several of the institutions involved in the case studies created a direct link between different forms of CBET and digital transformation in TVET. Kenya developed CBET policy framework and guidelines targeting the TVET level; these are currently being implemented towards move to more skill-oriented outcomes for students. However, CBET could not happen 100 per cent remotely in any of the countries, with some offering an 80-20 split (80 per cent distance learning and 20 per cent in-person learning).

While hybrid formats were associated with cost savings and improved access, the study also highlighted the impact on programmes requiring practical exposure. Although examples of hybrid formats were identified in Kenya, India, Brazil and Jamaica, very few (if any) of these programmes had been evaluated for their impact.

Educating learners and adults for general digital competence, such as what is happening in India, is noteworthy but not enough to future proof societies. Strong effective partnerships with industry to determine the competencies of new occupations is becoming more urgent as advancements in the tech space continue.

Digital transformation in TVET for teaching and learning using technology

The five case studies contain several examples of digital tools, including online teaching and learning platforms, blended and mobile learning courses, MOOCs, virtual and augmented reality, and simulations, being developed and/or used in the context of LMICs. However, the bulk of digital transformation in TVET in LMICs focuses on improving access to education through digital and blended learning platforms or delivery modes. Countries are still grappling with

digital divides; the changes in pedagogy necessary to effectively utilize these platforms; and educator and community capacity, particularly around digital skills.

LMICs still primarily focus on digitizing information and enhancing access to technology and connectivity. Efficiencies and effectiveness could be improved dramatically, but automation initiatives are still mostly nascent, even in those LMICs that can be considered as more advanced in the matter. The first efforts countries seem to make at this level consist in using LMS systems to gather student data for more informed teacher practice (in theory, and with many caveats). Distance learning is increasingly driven by a platform-based approach, and (LMSs) are among the first technologies to be introduced into TVET systems at this level. The observed benefits of LMSs include the ability to aggregate and store student data, and teachers' ability to refer to analytics to inform their practice. At the level of digital transformation, where new insights might be generated, the early efforts seen from leading LMICs centre on aggregating labour-market data and education data are to gain insights on skill-matching.

Lecturer capacity is a key challenge in pursuing digital transformation. The low technical capacity of ageing cohorts of TVET lecturers, and their resistance to being challenged by changing practices to accommodate technology and hybrid approaches, were common themes, accompanied by a general recognition that remote teaching does place an additional burden on lecturers. The SENAI case study in Brazil provided important and salient insights in its emphasis on 'people and culture first', followed by the need for technology to drive innovation and enhance processes and techniques for delivering education.

Teachers and lecturers must receive additional structural support to help them transform their practice and incorporate digital tools like videoconferencing and domain-specific software. Lecturers must learn how to review and curate content, and develop interactive and learner-centric multimedia courses. They need to understand the risks and advantages to remote learning, and how to repeatedly make data-driven decisions. Lecturer training must move from abstract concepts (e.g. theoretical descriptions of how to develop online courses) to concrete applications (e.g. teaching someone how to deliver specific content using a specific platform, textbook and resources). This dramatically lowers the 'bar to entry' for TVET lecturers, enabling them to apply the insights gained in training more quickly and efficiently. The Brazilian example demonstrated how this was achieved, although the process took considerable time, resources and effort to 'get it right'.

Despite the many challenges to the introduction of digital transformation in TVET, respondents across all five case studies were unanimous in their support for digital transformation in TVET as a means to promote more individual learning opportunities and provide more flexible learning (in terms of both time and location).

Contribution of digital transformation in TVET to sustainability and resilience

TVET institutions can contribute to sustainable development by ensuring that learners have the necessary skills and competencies to function in the digital economy and society, resulting in more opportunities and driving sustainable economic and social development. Thus, digital transformation in TVET in TVET institutions should include flexible learning pathways that recognize prior learning. For this to happen, new courses need to be upwardly stackable, credentialed and recognized by industry, as evidenced to some extent by the Brazilian and Kenyan case studies. Equally importantly, the person for whom these courses are designed may not fully understand (and should therefore be informed about) how they contribute to achieving a qualification (if applicable) or enhance future career opportunities.

New forms of credentialing, for example micro-credentials, are affecting how learning is recognized, and critically, how formal, non-formal and informal learning can be better articulated with jobs. Likewise, new forms of generative artificial intelligence (AI), such as ChatGPT, Copilot and Google Bard, are disrupting content creation at many levels, also raising critical questions about ethics and intellectual property. The TVET sector internationally stands to be more resilient and sustainable by involving itself closely in both these discourses, as well as testing and the research that will help chart the way.

It is well known that LMICs, by and large, have high percentages of young people. This youth dividend provides a huge opportunity to implement digital transformation in TVET, and by inference, to build more sustainable and resilient societies. Digital transformation in TVET can contribute to sustainable development and social resilience primarily by facilitating the provision of appropriately skilled and conscientious workers. A more seamless supply-and-demand system, facilitated

by the digital platforms identified in several of the case-study countries (notably India), can effectively identify the skills required for transitioning to digital and green economies.

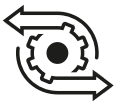
The research suggests that the digital transformation of TVETs can support the recommendation of the International Commission on the Futures of Education, released in 2021 (UNESCO, 2021), for a new social contract that considers broader issues of sustainability, shared norms and standards in TVET, new research collaborations, and targeted financing in areas where TVET can assist migrants, refugees and other displaced persons.

Recommendations

Table 2 below provides an overview of some key and practical recommendations for other LMICs.

Table 2. Summary of recommendations

Digital transformation in TVET level	Practical recommendation	TVET	Government	Industry	Unions	Student
Digital transformation in TVET for technical and technological development 	Follow a 'digital transformation in TVET-by-design' approach to infrastructure development to support the equitable digitization of TVET institutions and take-up of digital transformation in TVET.		✓	✓		
	Incentivize employer contributions for digital transformation in TVET (e.g. skill levies or secure private-sector investment).			✓	✓	
Digital transformation in TVET for curriculum and qualifications 	Build interoperable data systems to support digital transformation in TVET. Prioritize data-sharing between public holdings of citizen data, including facilitating the sharing of information between different current and future data systems.	✓	✓	✓		
	Expand recognition systems to embrace digital transformation in TVET. National systems of qualification recognition provide important platforms for individuals with skills obtained through experience in digital transformation in TVET for which they do not have a formal qualification. There is great value in introducing credit frameworks and aligning them with a standardized education system of credits.	✓	✓	✓	✓	✓
Digital transformation in TVET for teaching and learning using technology 	Build TVET trainer capacity in digital transformation in TVET. Prioritize training of vocational education and training (VET) lecturers so they can teach new occupational skills and forms of knowledge introduced by digital transformation technologies. Prioritize continuing professional development (CPD) of VET lecturers to utilize constructivist approaches that facilitate teaching and learning, and limit dependence on teacher-dominant styles of teaching.	✓	✓	✓	✓	
	Conduct focused research on digital transformation in TVET. It is expected that under the influence of digital transformation in TVET, teaching and learning will change at pace, and employer demand for skills will change in line with the digital transformation of businesses.	✓	✓	✓	✓	✓

Digital transformation in TVET level	Practical recommendation	TVET	Govern-ment	Industry	Unions	Student
Contribution of digital transformation in TVET to sustainability and resilience 	Promote inclusive digital transformation in TVET. Countries and institutions are encouraged to provide equal access to opportunities and resources to digital transformation in TVET in the TVET sector for any groups that are or may be excluded; this would particularly involve the demographically large male and female youth population in the region, as well as women in general.	✓	✓	✓	✓	✓
	Recognize that institutional culture also matters in a digital transformation in TVET context. Other than formal rules, such as regulations that govern behaviour, a TVET institution's institutional culture, values and norms of conduct, and interactions will inform how lecturers (and students) respond to changes.	✓	✓	✓	✓	✓

Source: Authors.

These recommendations are in line with an initiative launched in spring 2023 by UNESCO and the Global Education Coalition called Digital Transformation Collaborative (DTC) (UNESCO, 2023c). The DTC provides support to countries implementing digital transformation in their education systems using a framework of five components: Connectivity and Infrastructure, Content and Curriculum, Capacity and Culture, Cost and Sustainability, and Coordination and Leadership. A good way of implementing digital transformation in TVET as recommended by this report is through participating in the DTC.

Call to action

TVET systems are well-placed to use digital transformation in TVET to enhance their scope, scale, efficiency and effectiveness on many levels: technical and technological, curriculum and qualifications, and teaching and learning. The potential of digital transformation in TVET to contribute to more sustainable and resilient societies should not be ignored.

This document is a call to action for TVET policy-makers in LMICs to deepen their engagement with digital transformation and embark on the process of digital transformation in TVET. Interventions must be context-dependent and sequential, with early efforts at providing access to the infrastructure required for digital development and the digitization of information. Although the introduction of delivery platforms such as videoconferencing software and concrete digital tools such as LMS systems is easier on lecturers than other interventions, it must be acknowledged that the increased access to education through these platforms produces a heavier load for lecturers; attention must also be paid to preserving in-person practical components for most courses. On the administrative side, the use of LMSs for admissions, enrolment, course delivery and assessment has helped centralize information; early efforts towards digital transformation in TVET include gathering new insights on the supply and demand of labour through combinations of education and labour-market data.

While existing case studies provide road maps for digital transformation in TVET, some areas that can provide further efficiencies have not yet been adequately explored. Even the most advanced LMICs are not engaged in automating TVET processes – for example, by introducing partially automated grading or grading based on simulations, or using sensors for building maintenance or AI for other routine administrative tasks.

Policy-makers are called on to implement the lessons learned in their contexts, leveraging digital transformation in TVET to produce skilled citizens who contribute to a sustainable economy and more resilient societies, and a bright future for their countries.

Ultimately, the digital transformation of TVET systems can contribute to an equitable and resilient digitalization of LMIC societies, ensuring inclusion and the provision of necessary digital and non-digital skills.

01 Introduction

There is no doubt that technological advancements and digital transformation are reshaping the world. Across the public, private and third sectors, business models and operations are undergoing a transformation. They are incorporating technology and automation, assisting economic growth and sometimes even furthering other development goals, with extraordinary economic dividends and efficiency and productivity gains achieved in a wide range of sustainable development areas (ILO, 2019; UNESCO, 2018a; World Bank, 2016). Examples of the integration of technology into business processes include the following sectors:

- Agriculture, where farmers can use mobile phones to improve yields through sensor-based watering practices (Rehman et al., 2022).
- Health, where a patient can consult online with a medical specialist despite being located in a distant rural clinic (Chaitra et al., 2020).
- Infrastructure development, where agility, speed and data-driven decision-making can support multiple globally active projects (Sjodin et al., 2021).
- Environment, where blockchain is transforming approaches to biodiversity conservation (Parmentola et al., 2021).
- Education, where virtual environments are used to support learning (Pan et al., 2006).
- Finance, where all traditional banking services are now available 24/7 on mobile phones, without the need for customers' physical presence (Pennathur, 2001).
- Services, where AI-powered chatbots can address customer queries (Castillo, D., Canhoto, A. I. and Said, E., 2021).
- Commerce, where e-commerce has enabled individuals in rural communities to connect the products they develop with the markets, promoting broader labour-market participation and increased incomes (Luo, 2019).

These advancements, however, come with greater social divides between those with and without access to technology, and sometimes carry greater risks for workers. Those without access have fewer social economic and social opportunities (UNESCO, 2022b), a divide that extends across national borders as digital transformation spreads unevenly across countries (ILO, 2021a). And while digital labour platforms provide new sources of work, they may offer only unregulated casual employment, fixed-term contracts and limited protections, raising concerns about the availability of decent work as defined by the ILO[3] (ILO, 2021a).

Economic analyses indicate that the activities with the highest automation potential (and thus the highest potential to become redundant or relegated to non-traditional and vulnerable work) are routine-based jobs with predictable physical activities, such as machine operating, bookkeeping, data entry, processing and logistics (ILO, 2021a; ILO, 2022). Over a long period, high-income countries have offshored low- and medium-skilled jobs to developing countries, and it is precisely these jobs that are now under threat from digitalization (de Melo and Solleder, 2022). Further, the employees in the positions that are most at-risk of automation or technological disruption are the least likely to receive any on-the-job training or to have prior formal education (Nedelkoska and Quintini, 2018), and thus have lower chances of moving into higher-skilled work.

In LMICs, especially in regions where economic activity is limited to resource extraction or agricultural commodity production, the weight of labour-market demand tends to lean toward labour-intensive employment, while demand for digital skills depends on the services, manufacturing and trade sectors (ILO, 2021a). For example, with the automation of manufacturing taking place internationally, the 'assembly line'[4] skill sets required to build products out of spare parts are being replaced by individuals who can programme, repair and maintain the automated machines that now complete those tasks. In another example, bank tellers and office workers are increasingly being replaced by individuals hired to maintain platforms and websites. These kinds of transformations are only expected to increase.

> 'By 2025, 70 per cent of organizations will implement structured infrastructure automation to deliver flexibility and efficiency, up from 20 per cent in 2021.' – Bittman et al. (2023)

3. For a definition of decent work as given by the ILO, see: https://www.ilo.org/global/topics/decent-work/lang--en/index.htm
4. The assembly line format, in which each worker has and performs only one set routine task in a series of tasks which turn materials into outputs (for example, plastic pieces into a toy, or ingredients into a hamburger), was introduced by Henry Ford in 1913. It was first applied to the manufacturing of Ford automobiles but rapidly expanded to other products and sectors, becoming a nearly universal methodology for manufacturing until the advent of automation.

The increasing global use of digital technologies (such as mobile telephone technology), which is especially prevalent in the wake of the COVID-19 pandemic, is also driving change in the tools and modalities of learning, assessment and certification, was well as the provision of career guidance, job matching and labour-market services (ILO, 2021b). Given the current opportunities in the digital sector, the potential for personal development and national growth largely rests on a person's ability to *modify or produce technology*. And yet, due to limited opportunities in the local labour market and constrained access to digital skill-building programmes, there exists a real risk that LMICs will remain consumers rather than producers of technology – i.e. countries that use technology generated by others, generating additional data which are harvested to further advantage the producers of technology, and continuing to drive the international digital divide.

In this context, TVET and skill systems in LMICs need to be alert and responsive to the new skills required by different occupation, such as programmers, information and communications technology (ICT) security specialists or multimedia specialists. In so doing, they should ideally also engage in their own digital transformation by incorporating technology to improve their efficiencies, content, customer services and reach, all the while also managing the challenges this transformation presents to their institutions, staff and learners (ILO, 2021b). Drawing on the new UNESCO TVET Strategy for 2022–2029 (UNESCO, 2022b) as well as the UNEVOC analytical framework (UNEVOC, n.d.), digital transformation is inextricably linked to sustainable development and building resilient societies. Skill development has become a central pillar to address these future challenges, and the TVET sector is well-positioned to support the 'recovery, transition and transformation' UNEVOC, n.d.) the world needs more than ever before.

1.1 Defining digital transformation

What exactly is digital transformation? Recent work by the ILO (2021a) and UNEVOC (n.d.) and the GEC (UNESCO, 2023c; UNESCO, n.d.) has provided some groundwork to help understand what is meant by 'digital transformation' in general and the digital transformation of TVET in particular (digital transformation in TVET in this document). According to the ILO (2021a), digital transformation in TVET can be conceived as phases in the evolutionary process of an educational institution. When viewed this way, it is possible to differentiate between stages that institutions or individuals may go through as digital transformation in TVET progresses. The digital transformation of most institutions will begin with the conversion of information into digital data. It progresses through automation and the use of technology to 'streamline processes'. It culminates in *digital transformation*, 'where a whole-of system digitalization strategy' impacts the entire system, from the individual TVET institution all the way to the overarching level of the national skill system (UNEVOC, 2021). There are three stages of transformation: (1) digitisation, which includes the representation of information into digital data, and the organisation of that information in digital systems; (2) digitalisation, in which processes are automated using digital tools, and later streamlined with optimization of digital applications; and (3) digital transformation, when the whole institution is transformed (Reinitz, 2020). It bears noting that the transformation of institutions and systems is directly reliant on the acquisition of new digital skills (including digital literacy, data literacy, technical skills and digital threat awareness[5]) by practitioners, managers and policy-makers.

The most recent work by the GEC (UNESCO, 2023c) highlights important touchpoints with TVET, and in particular digital transformation in TVET. The first is a recognition that digital technology in education is evolving into a human right as educational ecosystems undergo transitions. Importantly for the digital transformation in TVET framework presented below, the GEC acknowledges that 'equity and inclusion have not driven global digital transformation', and that as a result, LMICs are at a disadvantage (UNESCO, 2023c, p. 1). As a response, the GEC proposes a framework comprised of five components across different levels of maturity (emerging, maturing and excelling): coordination and leadership; cost and sustainability; connectivity and infrastructure; capacity and culture; and content and curriculum.

All three initiatives mentioned above (ILO, 2021; UNEVOC, 2021; UNESCO, 2023c) point towards digital transformation as a complex process with different impacts depending on the economic sector. In the education and training sector, digital transformation

5. https://www.forbes.com/sites/bernardmarr/2022/07/22/the-4-digital-skills-everyone-will-need-for-the-future-of-work/?sh=2d225080a7e2

in TVET can involve TVET operational systems (administration, finance, human resources, building infrastructure and maintenance, student registration, etc.); classroom delivery (learning management, instructional delivery methods, etc.); and the actual knowledge and skill component of the curriculum, for example, by integrating the use of productivity software such as word processors or spreadsheets into students' learning outcomes. The integration of digital skills into the TVET curriculum allows learners to acquire the changing skills and knowledge (tacit and explicit) required to succeed in a digitalizing society, economy and labour market. Digital transformation in TVET is also profoundly transforming the dominant modalities of traditional face-to-face learning and teaching to involve multiple configurations of actors (learners, teachers and technologies/apps) in space and time (when, where, who, how). This means that digital transformation in TVET offers opportunities for teachers to reconsider their pedagogical assumptions, behaviours and relationships with students.

A definition of digital transformation in TVET

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.

Digital transformation in TVET takes place across four levels of increased complexity and sophistication:

- **technical and technological**
- **curriculum and qualifications**
- **teaching and learning using technology**
- **sustainability and resilience**

At the 'Transforming Education Summit' on September 2022 in New York, United States, UNESCO and UNICEF proposed keys for unlocking the potential of digital learning. That discussion led to the creation of the DTC, a group of members of the GEC who are committed to cooperatively developing long-term, synergistic partnerships with countries to improve lives through digital technology in education.

1.2 A digital transformation in TVET framework

At a first level, digital transformation in TVET is enabled and supported by systems, data and efficiencies. This includes a wide range of technical and technological applications and interventions, which can broadly be classified as *infrastructure* and *administrative*.[6] 'Infrastructure' refers to procuring the hardware, software, connectivity, human resources, space and other resources required to integrate technology into a TVET campus or system. 'Administrative' uses of data include student enrolment, course and completion records, staff records, performance appraisals and financial records. For this technical and technological layer, the first step is to establish the infrastructure and processes necessary to digitize information (e.g. transitioning from document records to digital records). Once this is achieved, records and information from different divisions or sources can be exchanged and organized in new ways, such as using enrolment and student-satisfaction data to inform human-resource processes or infrastructure planning and maintenance, compiling information on student performance into governance reports. This can be followed by automating some routine processes (e.g. payroll, routine procedures or report outputs). Digital transformation would be achieved when these processes, reports and synergies influence or drive TVET strategy, such as to determine staffing needs or allocation, or flag TVET infrastructure due for repairs.

This second layer deals with *the transformation of curriculum* and *qualifications*, or the introduction of new knowledge and skills into the curriculum. This could include new courses or skills, for example in cybersecurity, programming or cloud computing; it could also mean integrating digital skills into other courses, for example, including the ability to create PowerPoint presentations or use spreadsheets as learning outcomes for general courses. Here, digital transformation would be achieved if, for example, enrolment and student survey data are synthesized with industry and partner data to determine new skill needs and necessary curriculum revisions.

The third level refers to the *transformation of teaching and learning using technology*. At this level, digitization would involve incorporating digital learning records, for example, by transitioning from paper grades,

6. The DTC Framework refers to connectivity and infrastructure at this level (UNESCO, n.d.)

assessment records or evidence portfolios to their digital equivalents. The organization of data likely involves use of an LMS. The streamlining of processes could include:

- new methods of instructional delivery (e.g. using blended or remote learning)
- new tools for learning and assessment (e.g. using digital or remote assessments, automated grading, and multimedia resources or simulations)
- new methods of pedagogy (e.g. incorporating design thinking, project-based learning, 'flipped classrooms' which emphasize independent learning prior to lecturer engagements, or the 'use-modify-create' digital learning framework)

Digital transformation would be achieved when teachers and students are able to engage effectively through digital modalities, using digital tools and associated pedagogies, significantly improving access to the institution or system for students and producing equivalent or better learning outcomes than traditional methodologies. While supported by the underlying layers, TVET teachers can extend their theory and practice in innovative ways, and provide space for students to expand their creative potential. This layer opens the possibility of TVET lecturers and/or students creating new products, tools and engagement strategies, and new ways of teaching and learning using the ever-expanding repertoire of available digital technologies and tools.

The fourth and more advanced level of digital transformation in TVET is the *contribution of digital transformation in TVET to sustainability and resilience,* which refers to digitally enabled practices in TVET that contribute to sustainable development and resilient societies. On this level, the GEC suggests adding capacity and culture (UNESCO, n.d.). In this case, we have taken our lead from the UNESCO TVET Strategy for 2022–2029 (UNESCO, 2022c). The strategy envisions TVET as playing an integral role across several lines of action and activities, including the following, which are relevant to digital transformation in TVET while placing equity at the heart of policy (UNESCO, 2023a):

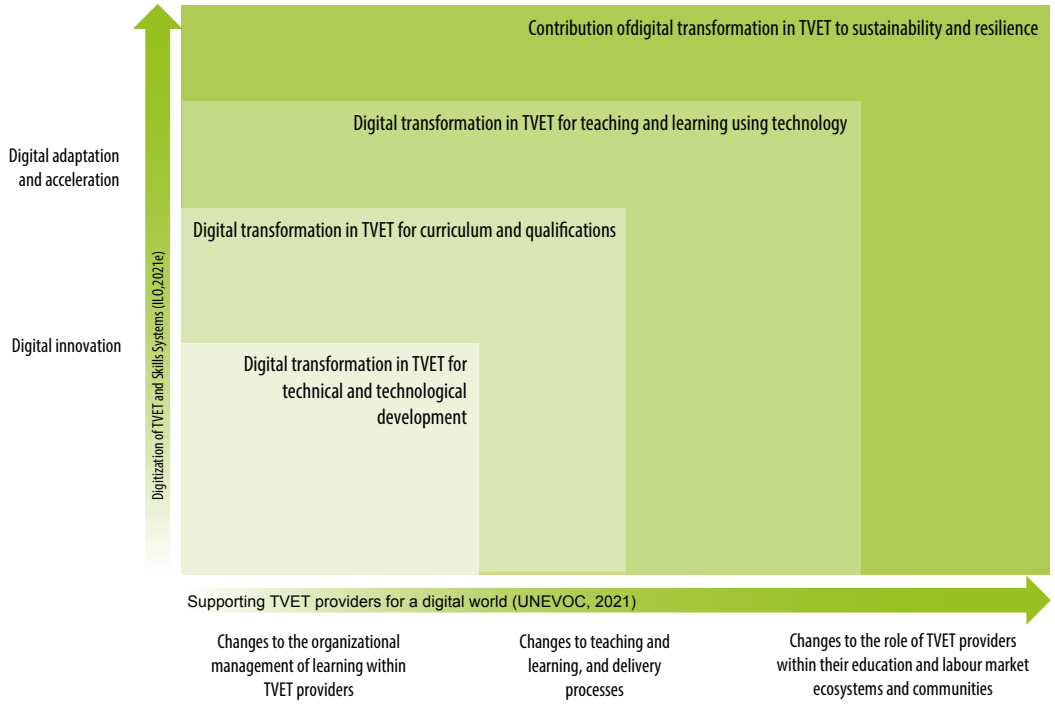
- identify the skills required for transitioning to digital and green economies
- deliver TVET to address youth unemployment and meet demands for inclusive digital and green transitions at the workplace, online and in other learning settings
- enhance science, technology, engineering and mathematics skills, and foster entrepreneurial and 21st-century skills
- support the teaching workforce and TVET institutions to foster quality, innovation and excellence
- reinforce governance and unlock investment
- integrate rights-based education for global and participatory citizenship
- promote TVET institutions as places for social integration, cohesion and green citizenship

Digital transformation in TVET would not be enabled without two cross-cutting components, which are part of the broader policy and regulatory frameworks for TVET. The first is the necessary human and financial resources (also see UNESCO, n.d.). Digital transformation in TVET requires funding at all four levels of the conceptual framework described above. Infrastructure is critical at the technical and technological level, to reform and digitalize curricula and qualifications, to train TVET practitioners in using new technologies, and critically, also to support sustainability and resilience. The second cross-cutting component is a quest for ongoing and deepening digital innovation across all levels of the conceptual framework. As described by the ILO (2020a), it is useful to think about innovation in digital transformation in TVET across three categories:

- digital innovation (how tech enables new forms/ pedagogies of teaching and learning in TVET)
- digital adaptation (how tech requires teaching of new skills in TVET to adapt to the changing needs of society and the labour market)
- digital acceleration (how tech may accelerate existing policies – massification, inclusion, exclusion and unemployability).

The four-level conceptual framework used in this study builds on the existing frameworks found in recent literature, including from the ILO (2021d, 2021e) and UNEVOC (2021) referred to above. Figure 1 below provides an overview of the complementarities between the three frameworks.

Figure 1. Four-level conceptual framework for digital transformation in TVET



Source: Authors.

1.3 Research design

LMICs are rising to the challenge of digital transformation in TVET. Successful implementation of various forms of digital technology is steadily increasing in many LMIC TVET institutions, despite substantial challenges related to infrastructure and human resources. The present research contributes to the conversation by exploring digital transformation in LMIC countries, focusing on the types of digital transformation in TVET, the ways in which digital transformation is happening and the lessons learned from digital transformation in TVET efforts. This work is an opportunity for policy-makers, TVET administrators and practitioners to reflect on the digital transformation of their own institutions and countries, considering the lessons of others to broaden their own efforts at using technology to improve TVETs.

The framework described above provided the study with a pragmatic lens through which to explore existing practices in LMICs, with a view to drawing out best practices and lessons learned from practitioners at both the governance level and on the ground. The desktop research and case studies sought to better understand:

- existing practices and trends in digital transformation in TVET in LMICs
- how TVET stakeholders in LMICs can use digital transformation in TVET to improve their TVET systems and skill development, including lifelong learning opportunities
- how TVET practitioners introduce digital transformation in TVET concepts into learning and teaching, including the lessons learned
- the effects of digital transformation in TVET on teachers and students, including learning outcomes and entry into the world of work

Table 3. Overview of digital transformation in TVET case studies

Case study	Country context	Data collection
Brazil	The National Service of Industrial Apprenticeship (Serviço Nacional de Aprendizagem Industrial [SENAI]) is Brazil's national training institute providing short-term vocational training, as well as secondary and post-secondary technical courses. The case study on Brazil focuses on the Programa SENAI de Padronização Educacional (SENAI Programme for Educational Standardization), which offers an example of how technology was used to standardize the administrative and managerial processes in adapting in-person traditional courses to online and hybrid ones.	Document and literature review; eight key informant interviews (conducted in Portuguese)
India	The case study focuses on the digital transformation journey taking place in the TVET space in India. Despite being classified as an LMIC, India has been making significant strides in its digital transformation journey across various sectors. In the education sector, India has introduced and implemented various methodologies and remodelled the education sector over the last ten years.	Document and literature review; five key informant interviews (conducted in English)
Jamaica	A small island nation with a population of about 2.8 million, Jamaica is currently invested in its 'National Strategy to Develop the Global Services Sector', which hinges heavily on ICT skill development. While access challenges persist (particularly in rural areas), 68 per cent of the population had access to the internet as of 2018.[7] While experiencing many of the same technical, cost and access challenges typical of developing states, Jamaica has shown progress towards digital transformation in TVET through innovations such as the National diagnostic assessment and referral system (NDAR),[8] a centralized application system for TVET training, and its Labour market information system (LMIS),[9] which draws quantitative and qualitative information from various sources to provide job-matching opportunities. Although efforts to digitalize Jamaica's TVET system have been ongoing, the COVID-19 pandemic precipitated the use of blended learning methodologies at the institution level.	Document and literature review; five key informant interviews (conducted in English)
Kenya	Kenya is one of the leading countries in Africa in terms of the application of digital transformation to help citizens transition to the modern age. The government achieved this without leaving out of the mainstream economy those on the margins, recognizing that a large portion of the population relies on the informal economy for its livelihood (although there are always gaps). The introduction of M-PESA to the Kenyan financial sector is one such government-led intervention that made it possible for Kenyans from all walks of life to gain access to the mobile payment economy, with minimal requirements other than ownership or access to a mobile device.	Document and literature review; four key informant interviews (conducted in English)
Tunisia	There is an imperative in Tunisia to combat unemployment among young people, a recognized national challenge, in addition to improving the skills of the currently employed adult workforce. Regional unemployment disparities exist between the interior and coastal regions, as well as gender disparities especially in the interior regions, where female labour-force participation is low. This raises the question of what role TVET offerings can play in meeting these needs. Unemployment rates are high, but a high proportion of job vacancies advertised by public employment services are not filled, pointing to a skill mismatch.	Document and literature review; six key informant interviews (conducted in French)

Source: Authors.

7. https://data.worldbank.org/indicator/IT.NET.USER.ZS?locations=JM
8. https://ndar.heart-nta.org/About.aspx
9. https://www.lmis.gov.jm/

1.4 Structure of this report

This report is structured in five sections:

a. Section 1 provided the background context, a definition of digital transformation and the conceptual framework used for the research.

b. Section 2 provides an overview of digital transformation in TVET, based on an extensive review of relevant literature.

c. Section 3 provides a summary of each case study, followed by a set of cross-cutting observations.

d. Section 4 responds to the key research questions by drawing on the findings from the literature review and the case studies, and presents a set of cross-cutting findings.

e. Section 5 provides recommendations for policy-makers and directions for future research.

Sections 2–5 are structured under the thematic areas outlined in the conceptual framework, as follows: technical and technological transformation, curriculum and qualifications, transformation of teaching and learning, and the contribution of digital transformation in TVET to sustainability and resilience.

02 | Digital transformation in TVET

2.1. Technical and technological and transformation

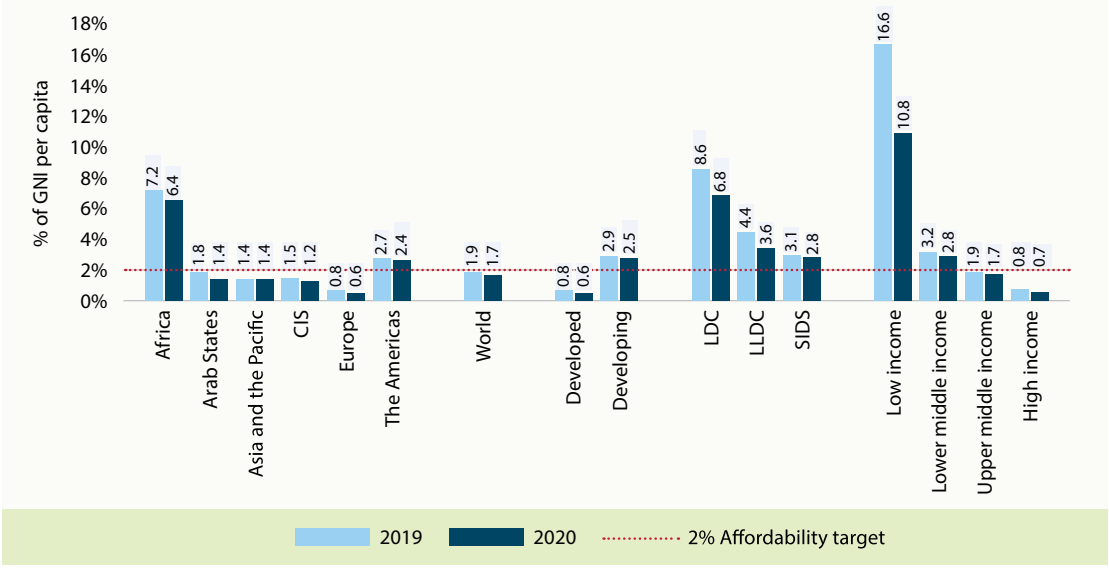
To play a significant role in achieving the SDGs and building resilient communities, TVET systems must overcome significant systemic challenges. A core challenge concerns access to technology, which is influenced by factors such as gender, cost and connectivity, as outlined below.

The Mobile Gender Gap report by the GSMA[10] (Shanahan, 2022) shows that the gender gap in access to technology is narrowing, but still hovered at 16 per cent in favour of males in LMICs in 2021, up from 15 per cent in 2020. The gap is largest in South Asia and sub-Saharan Africa, where males are respectively 41 per cent and 37 per cent more likely to own a mobile device than women. By region, the gender gap has decreased in 2021 in Latin America & Caribbean, to 1 per cent, and East Asia & Pacific (2 per cent), but remained mostly unchanged in Europe & Central Asia (5 per cent), Middle East & North Africa (16 per cent) and Sub-Saharan Africa (37 per cent). The gender gap in South Asia is the highest, it was 67 per cent in 2017, 36 per cent in 2020, but rose again to 41 per cent in 2021 (Delaporte and Bahia, 2022).

Particularly in Africa, major infrastructure challenges affect how quickly citizens and economic sectors can move towards digitization, a factor also influenced by the prevalence of informal work, as individuals working as street vendors or day labourers are unlikely to be connected. Ultimately, while 2G and 3G network coverage nearly stands at global averages, only 33 per cent of adults in Africa use the internet, compared to a global average of 50 per cent (Ndulu et al., 2021).

While there are exceptions, most LMICs – particularly low-income countries – bear the highest mobile connectivity costs; these are proportionately much higher in a lower-income country than in a higher-income country (UNEVOC, 2022). Connectivity prices are based on an international interconnected network, much like an airline, without a sliding scale of charges or costs predicated on location or national income. This further disadvantages lower-income countries and their citizens since few can afford to access the opportunities provided by the internet, and those that do spend a greater portion of their income to do so. Figure 2 below gives the price of mobile broadband data as a percentage of gross monthly national income per capita across different regions of the world. The dotted line denotes the 2 per cent 'affordability threshold' determined by the Alliance for Affordable Internet.[11] Its placement clearly demonstrates that LMICs are above the affordability threshold, while higher-income countries are below it.

Figure 2. Data-only mobile broadband prices as a percentage of monthly gross national income (GNI) per capita, 2019–2020



Source: UNESCO-UNEVOC, 2022.

10. https://www.gsma.com/
11. See: https://a4ai.org/

Even once access is achieved, the high cost of data, a lack of support for teachers in making the transition, short timeframes for digital adoption, and limited or ineffective training have led to low motivation to embrace a new digital landscape of teaching and learning (UNESCO, 2022). Moreover, because of the gendered divisions of labour in many households, female teachers and trainers have less time than their male counterparts to acquire learn new technologies and how to manage virtual workspaces and classes (UNESCO, 2022).

Over and above the need for foundational infrastructure, the integration of technology in TVET systems at this level requires commitment and political will. Government, institutional stakeholders and citizens must agree on the need for digital transformation and prioritize this expense. This alignment can be achieved through advocacy or other campaigns. A good example is the 'Digital Bangladesh' strategy, which has become nearly synonymous with the Awami League Party, which first introduced the idea in 2008 as part of a major campaign that included the introduction of technological infrastructure in the country as a key component of the party's manifesto. The strategy has helped increase internet access by a factor of 100 and quadrupled the country's gross domestic product in 13 years (Chowdhury, 2021). Today, the country even celebrates 'Digital Bangladesh Day' every year.

It is important to understand that the access gap is not just based on physical infrastructure and connectivity. The International Telecommunication Union (2019) details additional factors that could inhibit access to connectivity, including a market-efficiency gap in which those who could invest in connectivity do not, as well as the 'smart subsidy zone' in which a judicious investment from government could result in access. Predictably, the true access gap is experienced by households with the lowest income. UNESCO-UNEVOC (2022) emphasizes that it is the most marginalized populations which lack access. It notes that in 2019, 80 per cent of students in sub-Saharan Africa and 50 per cent of students in Southeast Asia lacked internet access at home, with individuals in the lowest 20 per cent of income unlikely to even own a radio in LMICs. This means that remote TVET interventions are unlikely to reach at least some of those who might benefit the most from them.

Policy can also play a prominent role here. There are many examples of governments enacting policies aiming to promote or benefit from digital transformation, including by investing in the foundations of digital transformation – i.e. infrastructure, basic education, higher education and research – and providing subsidies to companies to accelerate the transition. In addition, countries have defined regulations governing digital transformation, designed national plans to digitize government, established departmental and/or central authorities for digital technologies and created associations or shared governance models with the private sector (World Bank, 2021a). With regard to LMICs in particular, the literature has many recommendations for promoting digital transformation in TVET and 'Industry 4.0' (ILO, 2019; OECD, 2019; UNESCO, 2020; World Bank, 2021b; ILO, 2022).

The UNESCO programme 'Better Education for Africa's Rise II (BEAR II)' supported digital transformation in TVET in several countries. Particularly in Uganda, it provided ICT equipment to TVET institutions to increase their capacities and train work-ready graduates in agro-food processing and post-harvest management. Furthermore, interactive smart boards were procured to support the training of teachers and relevant TVET and teacher-training departments to promote their potential for strategic management. In 2022, 146 TVET teachers from 20 TVET institutions were trained on 21st-century skills and benefited from strengthening the curriculum in these areas.[12]

2.2. Curriculum and qualifications

Digital competence is an important requirement for learners to succeed in their studies, employment and ongoing development in the workplace. Serval emerging frameworks for digital competence have been developed in recent years. Broadly, as noted below by Lee et al. (2022, p. 2):

[TVET teachers] need to develop a range of technical skills in terms of digital pedagogy as well as an understanding of how learners are learning more individually or collaboratively through a multitude of technology-enabled methodologies, including game-like learning environments and simulations. However, in doing this they also need to blend these new forms of knowledge with the parts of the TVET teacher skill set that continue to endure and remain relevant while evolving with technological change.

12. https://en.unesco.org/themes/skills-work-and-life/bear

Several factors need to be addressed in this respect. First, there exist some challenges in devising a single unified formulation of competence, for several reasons. From practical skill-based programmes at the certificate level (e.g. nail technician), to intermediate diplomas (e.g. accounting), through associate degrees (e.g. engineering), there clearly exist many different digital competence levels. It follows that TVET teachers' digital competencies are also crucial if TVET students are to succeed in the labour market. Again, the digital competence necessary for different types of TVET teachers poses pressing questions. The UNESCO-UNEVOC practical guide on 'Promoting Quality in TVET Using Technology' categorizes the range of necessary high-level digital skills as follows: (1) use of digital technologies to enrich pedagogical techniques and practice; (2) use of technology to better manage learning needs and learner experiences; and (3) teaching digital skills, including how to use digital technology and tools. These digital skills or competency frameworks emanate from the UNESCO 'ICT Competency Framework for Teachers' and the European Commission's 'Competency Framework for Teachers'. These examples indicate important approaches, but also suggest further complexity (UNESCO-UNEVOC, 2020b).

2.2.1 New skills required by the labour market

The widespread introduction of emerging technologies into the labour market has resulted in two substantive effects. First, the skill requirements for jobs, particularly those related to technology, have outpaced the workforce's growing education levels. Technology has increased the demand for higher-skilled workers, enabling them to demand higher wages and leading to growing wage inequalities identified as early as 2013 (Schmitt et al. , 2013). Second, routine repetitive tasks are being replaced with more efficient technology-based systems (Masriadi et al., 2023).

Both effects have direct consequences for educational institutions and education systems, including TVETs, which must respond to the increased demand for digital skills by offering relevant programmes for students. Since a growing percentage of middle-skill jobs require productivity software even at the entry level (Burning Glass Technologies, 2017), TVETs must ensure that all students are equipped with the skills to handle basic software packages such as word processors, spreadsheets and presentation software. At the same time, growing ICT sectors (and the growing role of ICT in other sectors) mean that skilling systems need to deliver high-quality, relevant digital skills for the economy. The skills in demand include AI, programming, development, cybersecurity, cloud computing and data analytics (merSETA, 2020; European Software Skill Alliance, 2021; World Economic Forum, 2020).

2.2.2 New skills required by students

Students need additional skills to benefit from online TVET programmes (ILO and UNICEF, 2022). In addition to basic digital skills, they need specific online learning skills, including the use of online platforms, online document editing and collaborative tools, and online communication tools with the instructor, administrative staff and other students (World Bank, 2021a). Some programmes introduce students to basic digital and online learning skills (Cedefop, 2022). Students also need access to infrastructure, which may include a computer, a stable internet connection, a microphone and a camera, and a quiet place for studying and taking classes (OECD and World Bank, 2022). Because of these requirements, some students may face different or additional barriers to taking online programmes.

2.2.3 New skills required by teachers

The attitudes, behaviour and skills of TVET teachers influence their 'use of digital tools and services for teaching TVET' and their commitment 'to the digital delivery of TVET through distance learning' (UNESCO, 2022b, p. 8). Table 4 outlines the technical and pedagogical skills teachers need to support student achievement.

Table 4. Emerging use of available ICT tools

Applying	Using productivity tools for teaching and learning
Infusing	Integrating ICT tools in programmes to accommodate learning needs
Transforming	Using to support and empower students to advance their skills

Source: Based on UNESCO, 2022.

One of the primary challenges in introducing technology and innovative pedagogies in classrooms is lecturer capacity. In 2021, UNESCO-UNEVOC, together with Omnia Education Partnerships, offered a three-month training for TVET managers, teachers and ICT staff in Jamaica, Kenya, the Maldives, Nigeria and Peru to help build digital capacities in the wake of the pandemic.[13]

To respond to ICT skill requirements, many teachers need to acquire new skills or upgrade their current skills. According to UNESCO (2022), the following aspects of knowledge are required:

- Digital pedagogy skills. Students must know how to search, select and plan the use of online materials, tools and features to prepare their course (UNESCO, 2020).
- The ability to adapt teaching practices. Teachers must adapt pedagogical content, knowledge, materials and evaluations to online environments (UNESCO, 2022b).
- The ability to use, and teach students to use, a learning platform and its functions such as synchronous assignments (online classes, group assignments) and asynchronous assignments (readings, homework, etc) (UNESCO, 2020). Teachers must be able to generate a good-quality process.

In addition, teachers need to understand the use of technologies to support learning and teaching. Bozalek et al. (2014) suggested that digital technologies can support the transformation of pedagogical practices from a didactic to a transformative mode, aligned to authentic learning (Reeves et al., 2004) and assessment (Wiggins, 2011). This suggests that to fully utilize digital technologies, teachers must acquire basic digital skills, master the use of learning platforms and digital tools required for courses, be able to adapt content to the online environment, and finally understand the ways in which the online environment will change the interactions between themselves and between learners. Hence, TVET institutions must provide teachers and trainers with training and capacity development to enable them to offer high-quality online programmes (ILO, 2020a).

The UNESCO programme 'Youth Employment in the Mediterranean' contributes to improving qualifications in the region's countries. For instance, there are tangible results in the three key areas of digital, entrepreneurial and life skills. A skill platform was introduced in 4 four countries, reaching 180 teachers and 14,400 students. The entrepreneurship training in Palestine led to events in three regions. In Lebanon, the life skills approach resulted in the creation and publication of the 'Life Work Skills Toolbox', which may also be used in Jordan, Palestine and Libya.[14]

2.3. The transformation of teaching and learning

As noted in Section 1, pedagogical transformation is grounded in the introduction into the classroom of new technologies and tools, combined with new pedagogies to support the optimal use of these digital tools. The framework outlined three broad categories for consideration: methods of instructional delivery, new tools for learning and assessment, and new methods of pedagogy. This subsection unpacks concrete examples in each category.

2.3.1 New methods of instructional delivery

Online teaching and learning

One of the most influential ways through which digital transformation is influencing education systems in general, and TVET specifically, is through online teaching (OECD and World Bank, 2022; ITU, UNESCO and UNICEF, 2020; ILO and UNESCO, 2020). During the COVID-19 pandemic in particular, many national TVET programmes included online assignments or migrated towards open and online teaching (World Bank, 2020; UNESCO, 2021; ILO, 2021, 2022).

Digital technologies have also provided the means to transition from traditional higher education and TVET involving teacher-driven didactic classrooms to more interactive online internet-based systems (ITU, UNESCO and UNICEF, 2020). However, increased access to online teaching and learning opportunities has not automatically encouraged teachers and trainers to experiment with ways of improving traditional teaching methods. Many TVET lecturers have retained didactic and teacher-centric face-to-face methods even as they transition to online

13. https://unevoc.unesco.org/home/Digital+Transformation+in+TVET
14. https://en.unesco.org/themes/skills-work-and-life/yem

delivery, ignoring accessible and simple digital learning approaches and tools designed to encourage active participation (OECD and World Bank, 2022).

Blended learning

Before the large-scale availability of the internet, distance education was correspondence- and print-based, possibly been augmented with radio, television or audioconferencing. It did not incorporate interaction between learners and instructors or co-learners, despite the programmes' requirements for hands-on experiences and learning outcomes including social interaction skills (ILO, 2021b). Today, the internet has enabled blended learning, which combines individual online learning with in-person interactions (ILO, 2020a; ILO, 2021a; UNESCO, 2021). Distance education can now include student-teacher and student-interaction through collaborative tools such as blogs, wikis, podcasts, open educational materials, chat rooms and online forums[15] (World Bank, 2021b; ILO, 2021a, 2021b, 2022).

However, the blended learning research and practice has 'not yet provided sufficient guidance on supporting the creation of an immersive blended learning environment, which is seen as an essential aspect to improve and contextualize learning experiences for twenty-first century learners' (Bizami et al, 2023). One solution is grounded in constructivist theories, with a focus on encouraging students to 'construct new knowledge based on their previous experience' (Al-Huneidi and Schreurs, 2012, p. 1). However, this is still a very limited approach to constructivism, which in essence posits that learning takes place through interactions between individuals, and between individuals and the environment. In-person interactions can be used to increase the social connection among students and enhance overall positive experiences for students (Farliana and Mulyono, 2018; UNESCO, 2021).

Mobile learning

The of MOOCs has represented one of the most transformative developments in education of the last 15 years, but a more interesting development was the parallel rise in the use of mobile devices to support learning (Stöhr, 2017). Sharples et al. (2016) concur that mobile learning does not just allow accessing education on small devices, but also forces those involved in education to reconsider the experience and context of mobile learners, including the role of teachers and technology in supporting them.

Mobile devices such as smartphones and tablet computers can support remote and blended learning. Today, there is no need to develop content (e.g. websites or apps) specifically for mobile devices, which can access general websites and use the same apps as computers. Mobile phones are the predominant device through which many citizens from LMICs access the internet. Sharples et al. (2016) studied mobile device use by MOOC students and found that those who use them the most tend to be younger, have degrees or equivalent qualifications, and are predominantly male. Therefore, mobiles are an important vehicle for expanding learning possibilities for TVET students.

2.3.2 New tools for learning and assessment

Learning platforms

A learning platform is a software environment used for education and training, e-learning or digital learning as part of the instructional delivery strategy of public or private institutions. Different kinds of platforms can be designed to meet the needs of particular learning populations.

LMSs such as Moodle, Google Classroom and Blackboard have evolved over the last few decades to include more sophisticated forms of predictive guidance and adaptive learning pathways using algorithms. The interface between these platforms (which are mostly based at the place of employment or educational institution) and broader national data systems may be less advanced, but there is a strong push for increased interoperability[16] across such systems internationally (Shiohira and Dale-Jones, 2019).

Massive open online courses (MOOCs)

A MOOC is an online learning course designed for large numbers of geographically dispersed students. MOOCs have been used as a platform for presenting TVET programmes (Khan et al., 2018;; Mazin et al., 2020).

15. In addition, such systems can collect administrative data.
16. 'Interoperability' refers to the ability of systems, or components of a system, to seamlessly (usually automatically) exchange information with each other. One example is the manner in which a mobile phone registers an email as 'read' once it has been accessed on a computer.

Some MOOCs emphasize networks between participants and the sharing of resources (Bozkurt et al., 2018), but most MOOCs are educator-led instruction featuring content for mass consumption (Stracke, 2017). In these MOOCs, the instructor is mostly responsible for preparing the course and monitoring public assignments on an online platform (Xing, 2019), and the student is expected to take the course and complete the assignments, mostly or completely independently.

The core value-added of MOOCs is their scalability, but there are limitations. While MOOCs can attract many participants[17], programme completion rates can be low at approximately one-third of enrolment (Shah et al., 2022). In addition, MOOCs have limited capability to assess complex and open-ended student assignments (Admiraal et al., 2015). As a result, there may be limitations to how this kind of platform can benefit TVET students. However, it must also be noted that in terms of gross numbers, MOOCs have huge potential: assuming a 33 per cent completion rate, a MOOC with as little as triple the enrolment of a traditional course will graduate the same number of skilled individuals as a traditional course with a 100 per cent completion rate.

MOOCs are often associated with open educational resources (OER).[18] Open courseware and OER are freely available and openly licensed instructional materials that can be used for online TVET programmes, thereby reducing costs (UNESCO, 2018). However, current research suggests that the greatest potential of OER lies in supporting a more equitable and student-centred learning approach, referred to as 'open pedagogy' or 'open educational practices' (Ehlers, 2011; Colvard et al., 2018). Open pedagogy implies student's use of OER in creating, rather than consuming, knowledge.

Generative AI

The November 2022 release of ChatGPT, a generative AI application, resulted in a groundswell of interest and expectations of what AI technology means for teaching and learning. There is no doubt these new developments already form an integral component of digital transformation in TVET and will impact all levels of learning. The current debates surrounding ChatGPT (see Bozkurt et al., 2023), and more recently also Copilot and Google Bard, as well as other more familiar open AI platforms such as DALL-E, highlight diverse perspectives and the potential impact on TVETs. The World Economic Forum[19] notes 'concerns about academic integrity', while also adding that 'worries over plagiarism and cheating should not overshadow the learning opportunities [generative AI] brings'. On the other side of the debate, well-respected cognitive scientist and modernist Noam Chomsky has been vocal in his criticism of such technologies as 'high-tech plagiarism', citing the 'false promise of ChatGPT'.[20] A recent study conducted by researchers from OpenAI and the University of Pennsylvania refers to a broader perspective on the impact of AI (Eloundou et al., 2023). It suggests that white-collar jobs, such as those within the 'information processing industries' (like information technology), are the most exposed to generative AI, while jobs in 'manufacturing, agriculture and mining', as well as those that only require a high school diploma, vocational school, or on-the-job training (including food-preparation workers, electricians, barbers and medical assistants) are the least exposed.

This aspect of generative AI is growing exponentially, and exploring it fully would require a separate report. That said, openAI is already impacting teaching and learning in TVET colleges, and policy-makers and practitioners should participate in these debates. The risk of generative AI being misused is very real, and the likelihood that OpenAI will serve the interest of the few over the many is even greater. Of particular consideration for LMICs is the potential impact of technology that draws its conclusions from a 'majority perspective', based on the 'most common themes' related to a topic. Such overreliance on 'artificial unintelligence' (Broussard, 2019) can have negative consequences, particularly in contexts that are seriously considering 'decolonizing education' (Mazrui and Wagaw, 1985; Smith, 2016) or seeking to promote (for example) minority languages or minority perspectives.

Simulations and immersive learning technologies

Learning simulations are complex real-life authentic tasks conducted in an environment that support

17. https://www.classcentral.com/report/mooc-stats-2020/
18. Open Educational Resources (OER) are learning, teaching or research materials in any format/medium that can be found in the public domain or that have been copyright but are released under open licence, that permits open no-cost access to re-use/purpose, adapt, or redistribute.
19. https://www.weforum.org/agenda/2023/03/chatgpt-and-cheating-5-ways-to-change-how-students-are-graded/
20. https://mymodernmet.com/noam-chomsky-chat-gpt/

experiential learning. They range from problem-based tasks to complex scenarios that closely resemble reality (e.g. virtual aviation environments) and didactic materials that mimic reality (e.g. manikins in medicine or nursing) (Ahn and Nyström, 2020; Breckwoldt et al., 2014). Simulations enable the acquisition of practical skills, experiential knowledge or other cognitive abilities (e.g. problem-solving skills that often cannot easily be performed in real-world situations), and therefore support pedagogical theory related to experiential learning, constructivism and situated learning (Kolb, 2015; Lave and Wenger, 1991; Ericsson, 2004).

Virtual and augmented reality

Virtual reality (VR) combines hardware and software to simulate a spatial three-dimensional world in a digital application people can navigate in an immersive experience (World Bank, 2021b). In the Metaverse, for example, people have digital avatars that can meet other people to conduct personal and professional activities (McKinsey, 2022). Similarly, augmented reality (AR), is a set of techniques that create digital projections on the physical world so that people can interact with physical and digital objects simultaneously (Ozdemir et al., 2018).

VR/AR applications are useful for simulating phenomena or environments in which students interact (Karstensen and Lier, 2020). For instance, a VR application has been used to simulate a manufacturing context and for collaborative work among students (Gonzalez et al, 2015). AR systems are also used in manufacturing and experiential learning (Goppold et al., 2022). Additionally, there is a growing need for secondary-level TVET graduates to operate and maintain VR/AR devices and applications, together with other high-tech trends (Cedefop, 2022; ILO, 2022).

Virtual and remote assessment

Emerging evidence from multi-country studies (ILO, 2021c; World Bank, 2021b) suggests that assessments associated with TVET certification, including trade tests, can be delivered in more hybrid forms. However, remote technology cannot replace certain components of skill-building programmes that are inherently practical and require face-to-face interaction or specialized equipment.

The COVID-19 pandemic required TVET systems internationally to grapple with the complexities of assessments and examinations using virtual and remote modalities. Guidance notes issued early in the pandemic advised countries to postpone theoretical and practical exams, and rely instead on 'past results to determine grades or assume that assessment [could] take place after COVID-19 measures [were] relaxed' (Levin et al., 2020, p. 6). As the pandemic progressed, online platforms such as the UNESCO-UNEVOC 'Toolkits for TVET providers',[21] launched in 2022, filled an important gap, assisting practitioners and policy-makers in managing issues related to remote assessments.

2.3.3 New methods of pedagogy

The majority of TVET learners enrolled for occupational development need specific hands-on experience to develop and exercise technical knowledge and skills, as well as opportunities to build the social skills related to workplace communication, teamwork, diversity, etc. (ILO, 2021d). While they cannot replicate the in-person experience, TVET programmes can adapt to hybrid or blended learning pedagogies that provide a mix of remote and in-person activities (ILO, 2020a, 2021b; UNESCO, 2021), and simulations which can also provide facsimiles that may replace or reduce the requirements for in-person hands-on experiences (ILO, 2019). Pedagogical transformation is necessary to both fully exploit and mitigate the risks of distance or remote learning.

One example of innovative pedagogies is digital game-based learning (DGBL), which some argue can promote critical thinking, problem-solving and collaboration; enhance knowledge acquisition; address misconceptions when playing together; and improve learning in different content areas (Sourmelis et al., 2017; Boyle et al., 2016; Foko and Amory, 2018; de Freitas, 2018). Feedback from these experiences indicates that students can feel lost and need support, signalling the need for peer and lecturer support, as well as a well-structured and supportive game platform. Structural elements to be addressed include user experience, social relationships and communication, user engagement and recognition of learning and achievements (Foko and Amory, 2018; Tüzün et al., 2019).

21. https://unevoc.unesco.org/home/Toolkits+for+TVET+providers

The Global Skills Academy, launched by UNESCO in July 2020, aims to help 10 million young people build skills for employability and resilience by 2029. Currently, 20 members of the GEC are contributing to the GSA's mission through free and high-quality online trainings. For instance, Conecta Empleo, a partnership between Fundación Telefónica and SENATI in Peru, will provide more than 100,000 young people with access to training in key digital and employability skills in its 54 educational campuses.[22] Microsoft, for its part, is supporting the Technical Education and Skills Development Authority in the Philippines with training in digital skills. Since November 2021, over 17,000 learners in the country have signed up for Microsoft's Digital Literacy course, and more than 6,500 have already completed the training.[23]

2.4. The contribution of digital transformation in TVET to sustainability and resilience

Digital transformation in TVET is central to global sustainability (Gomez and Lorini, 2022; Chandola, 2015; Holzinger et al., 2021; UNESCO, 2021). Digital transformation, specifically from a TVET perspective, has the potential to contribute to several key areas explored in this section.

2.4.1 Digital ecosystem platforms

Digital platforms are central to managing the supply and demand of skills. A new generation of platforms embraces the complexities of entire ecosystems as technologies enable more sophisticated architectures than ever before (Chakroun and Keevy, 2023). In some countries and regions, the platforms are driven by the private sector; in others, there is strong involvement from governments (Shiohira and Dale-Jones, 2019). The five case studies included in this study present several examples of platforms that are developed within LMICs. While knowledge and understanding of both the potential and risks associated with the transition to ecosystem platforms are still nascent, the development of these platforms is a growing trend.

One potential benefit deriving from establishing these platforms is the inclusion of micro-credentials in learning records and recognition. Micro-credentials have recently garnered growing international interest (CEDEFOP, 2023; ILO and UNICEF, 2023; UNESCO, 2022d), and ecosystem platforms with a degree of digital interoperability provide an ideal infrastructure for knowledge, skills and competencies to be codified, recorded, aggregated and verified in real time.

Upskilling, reskilling (including providing skills required for the transition to the green economy) and lifelong learning also fit well into a logic that allows supply-and-demand ecosystem actors to collaborate more seamlessly through a common nomenclature. There is still much to be said and done with regard to digital ecosystem platforms, but have the potential to contribute to sustainability through flexible learning pathways and the recognition of non-formal and informal learning.

2.4.2 A new social contract for TVET

The report on the Futures of Education, released in 2021, firmly positions TVET as a critical sector for global sustainability (UNESCO, 2021). This call for global solidarity and international cooperation, including :

- shared purposes, commitments, norms and standards
- cooperation in knowledge generation and the use of evidence
- financing education where it is threatened

The report outlines 'a new social contract' and provides digital transformation in TVET with a clear vision, which includes broader issues of sustainability. Shared norms and standards in TVET will be key, as will be new research collaborations and targeted financing in areas where TVET can assist migrants, refugees and other displaced persons.

2.4.3 Skills for inclusive and peaceful societies

The UNESCO TVET Strategy for 2022-2029 argues for a line of action that focuses on skills for inclusive and peaceful societies (UNESCO, 2023a). This is an area that policy-makers and practitioners should take seriously when considering digital transformation in TVET, especially with regard to two aspects:

22. https://www.unesco.org/en/articles/global-skills-academy-new-partnership-deliver-skills-training-peru
23. https://www.unesco.org/en/articles/global-skills-academy-microsoft-supporting-digital-skills-trainings-philippines

- integrating rights-based education for global and participatory citizenship
- promoting TVET institutions as places for social integration, cohesion and green citizenship

These aspects can be addressed at the levels of the curriculum and pedagogy, but more broadly require institutional heads and policy-makers to explicitly factor them into strategies and frameworks.

The 'Bridging Innovation and Learning in TVET' project complements national developments to explore and support innovative, society-oriented modes of learning and cooperation in TVET. For instance, since 2019, it provides offline digitalization projects in Burundi and the Democratic Republic of Congo to support quality improvements in TVET teaching and training. These projects are based on 'Ideas Cube', a portable nano-server that creates a local offline Wi-Fi hotspot users can connect to using any device. It allows access to thousands of specially curated digital resources, as well as extending support in the use of technology-aided teaching methods to educators located in areas of the world that lack internet connectivity.[24]

2.5 Managing digital transformation in TVET in TVET institutions

Digital transformation in a TVET institution must be acknowledged as a complex challenge. The introduction of institutional digital technology (and the transformative use of technology in particular) involves the institutional leadership, the planning division, technologists, administration, and teaching and learning staff members (ILO, 2021d). As such, the capacity for digital transformation is strongly influenced by the skill of teaching, technical, administrative and management staff; financial resourcing and access to digital services; and other contextual considerations that may emerge between well- or poorly resourced rural or urban TVET campuses, and the communities and industry they serve. Students also need to be considered, particularly with respect to their access and capacity to utilize digital tools. As previously mentioned (Section 2.2), learning through technology is a skill that may need to be explicitly taught.

'Digitalization of education is a strategic goal in most national educx@ational policies. It poses challenges not only to teaching staff but also to TVET management, requiring organizational, personnel and teaching development as well as technical measures'.[25]

According to the ILO (2021a), there is currently no single framework or standard approach that can develop a digitalization strategy for skill systems. However, there are key principles that all managers and leaders in TVETs need to consider when implementing any digital transformation in TVET interventions within their institutions:

Social inclusion should be the key focus of any digital transition strategy; National skills systems need to become integrated systems; Digitalization of TVET and skills development requires specific digital solutions for this form of education and training; Digitalization is also about change management as digitalization changes almost every work role in a system; Building digitalization capability requires a holistic workforce development approach (ILO, 2021a, p. 1).

In 2020, Rujira, Nilsook and Wannapiroon analysed documents, theories and related research on digital transformation practices and processes in high-performing digital VET colleges. The research culminated in a synthesized framework consisting of five pillars (Table 5).

24. https://unevoc.unesco.org/bilt/Promising+Practices+in+TVET/lang=en/id=6634
25. https://www.giz.de/akademie/en/html/60955.html

Table 5. Vocational education college transformation process toward high-performance digital organization

Digital transformation framework	Vocational education colleges	Digital vocational education colleges	High-performance digital vocational education colleges
Policy		Organizational structure; Digital strategy	The 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 digital system; Learning process management by 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: Adapted from Rujira, Nilsook and Wannapiroon (2020), p.835. Available under CC BY 4.0.

A number of courses are available to help TVET management with their digital transformation, including the module 'Managing Digital Teaching and Learning' developed by the GIZ TVET Academy (GIZ TVET Academy, n.d.). In addition to providing TVET management personnel with an understanding of digitalization in the context of teaching and learning in TVET, this course offers managers skilling on deducing qualification requirements for TVET teaching staff, and deriving suitable and affordable digitalization options for their institutions.

In another example, UNESCO-UNEVOC is championing over 2022–2023 four digitization subprojects for TVETs. Although not solely geared towards managers and leaders, the subprojects assist them in solutioning for digital transformation in TVET, including by fostering digital partnerships and providing pooled resources through technology hubs such as 'fab-labs and makerspaces' (UNESCO-UNEVOC, n.d.).

Leaders in institutions are likely to differ in their inclination and capacity to respond to the challenges of digital innovation. In their progress towards digital transformation, some will emerge as innovators, some as adopters, and some as followers. When taken to the level of whole 'institutional change management', it is important to possess adequate conceptual models that help consider the challenges from a holistic perspective. In addition to a systems-wide approach accounting for the contextual factors of each institution, a grounded perspective on how the digital transformation in TVET agenda will advance is also necessary. Institutional change has a long timescale, and the scheduling of activities and milestones needs to be clear. Educause[26] has identified several high-level activities that must be achieved to support progress toward institutional digital transformations, including learning, planning and implementation.

26. https://dx.educause.edu/

Table 6. Digital transformation journey

Learn	Plan	Do
Define DX	Assess readiness	Assess your DX progress
DX and culture	Lead a conversation	Plan the next steps
DX and workforce	Develop a DX strategy	Learn from others

Source: Adapted from Educause. Available at https://dx.educause.edu/ under CC BY SA 1.0

2.6 Concluding note

The following section provides an overview of the five case studies undertaken in late 2022 and early 2023 in Brazil, India, Jamaica, Kenya and Tunisia. Each case study involved a set of five to seven key informant interviews and a review of all publicly available documentation, which form the sources of the information presented.[27] The case studies are analysed using the conceptual framework presented in Section 1.

27. Note that any and all uncited quotations are drawn from the participant research conducted for these case studies.

03 | Case studies

3.1. Brazil

3.1.1 Country context: Brazil

The National Service of Industrial Apprenticeship (SENAI) was formed in the 1940s as part of the National Confederation of Industry with the goal of providing a quality labour force to the expanding industrial sector (Barria et al., 2016). SENAI is organized at both the national and state levels as a private, non-profit organization and is financed, managed and led by industry through levy-based income. In recent years, SENAI has developed into an institution providing short-term vocational training, secondary and post-secondary technical courses as a standalone operation (Barria et al., 2016).

In addition to SENAI, the Brazilian TVET system is complemented by 41 federal institutes, state technical schools and private institutions (UNESCO-UNEVOC and National Council for the Federal Network of Vocational Institutions, 2018). Upper-secondary students enrolled in technical programmes represent 11.5 per cent of the total population. The National Education Plan 2014–2024 foresees expanded enrolment of TVET students by 2024, but this is unlikely to be achieved (Barros et al., 2018). A significant portion of secondary-level technical enrolment is in the evening shift, composed on average of older students with lower socioeconomic status. A recent study by Barria et al. (2016) found that graduates from upper-level vocational technical education obtain 30 per cent higher wages, are less vulnerable to unemployment and informality, and are more likely to nrol in a college education than those who completed secondary education at most

Table 7. Key statistics of TVET in Brazil

KEY STATISTICS

Vocational education	General education	Education finance
Enrolment in secondary vocational, both sexes (number)	Net Enrolment Rate, secondary education, male (%)	Government expenditure on education (% total)
956.6 thousand	80.3%	16.1%
of which female (%)	for female students	on vocational education (% of total)
54.6%	83.2%	not available

TVET INSTITUTIONS AND RESPONSIBLE MINISTRY

Federal institutions	National apprenticeship services	Private and Public Technical Schools
41 (2019)	2789 (2019)	1838 (2019)
Secondary and tertiary	Secondary and tertiary	Secondary
Ministry of Education	Ministry of Education	States

Source: UNESCO-UNEVOC Country Profile (UNEVOC, 2022a).

3.1.2 Case study: Brazil

The case study identified the 'Programa SENAI de Padronização Educacional', SENAI's digitalization experience aiming to create and provide hybrid TVET courses, as a key area if focus to explore the lessons learned from high-level decision-making as well as derive a more local perspective from instructors and teachers. Since its launch in 2012, a number of online and hybrid programmes have been created based on existing in-person programmes. The SENAI experience shows continuously increasing quality in the adaptation processes and course offerings from the perspectives of administrators, instructors and students. The COVID-19 pandemic increased the rate at which online and hybrid courses were adapted and offered; enrolment in those courses reached 65 per cent in 2022, compared to 40 per cent in 2019.

The SENAI Programme for Educational Standardization began in 2012 as SENAI was undergoing 'a generation change of its teaching professionals', where SENAI's workforce needed to increase to deal with demand and enrolment just as several trainers, lecturers and teachers were about to retire. In a bid to mitigate the loss of institutional memory and teaching expertise while simultaneously building its capacity, SENAI made a strategic move to use technology instead of increasing its infrastructure. The 'standardization' was a call for administrative and managerial processes to transform traditional in-person courses into online and hybrid courses. This transformation was underpinned by a primary focus on organizational culture. Digital transformation was implemented as a 'culture movement' with a view to 'changing people's mindset', followed by a deeper understanding of digital transformation in TVET that also involved changing the teaching and learning process itself. The programme restructured traditional processes by incorporating technology, then improving and enhancing the teaching learning process. Results from students' evaluations demonstrate better learning results in several programme areas, while teachers were more likely to better connect theory and practice using digital tools.

The creation of new online and hybrid TVET courses as part of the programme underwent nine stages (or standardized routes) before the first students were enrolled.

- Step 1 involved profiling to determine industry and learners' needs through 'prospective studies of technological foresight based on how technologies would be used in the next 5-10 years and also on the real demand of the productive sector'.
- Next, designing the competence-based curriculum (Step 2) and planning the course (Step 3) commenced.
- Once this was done, teaching plans (Step 4), textbooks (Step 5) and online lessons (Step 6) were developed.
- Additional supporting materials and resources such as teaching kits and reference simulators were then identified and developed (steps 7 and 8), 'not as mandatory standards but as references that teachers can use'. Once this was in place, teachers/lecturers/trainers/tutors were offered intensive programmes on content material and delivering the course.
- The last step was evaluation (Step 9), where students were surveyed to obtain both impact information (the student's employability) and their overall satisfaction with the course and its delivery.

The whole process was undertaken in collaboration with a wide network of subject-matter experts from relevant industries, as well as education and training experts who sit on national sectoral technical committees, with the aim of identifying and implementing best practices to ensure teaching and training in the relevant competencies. As of January 2023, this process has resulted in 70 technical courses, 233 certifications and 1,318 textbooks.

SENAI's efforts have revolved around 'creating a single methodology for creating new programs. Specialized technical and vocational content was primarily delivered in a hybrid, 'semi-face-to-face' format, where 80 per cent of the content is online (distance learning) and 20 per cent is delivered in-person in the classroom. However, changing the mindset and culture to one that involves open hybrid teaching and use of different technologies, applications and platforms posed challenges that required intensive awareness-raising, from top management to teachers themselves.

Respondents attributed the success of this programme to the competency-based nature of the programme, which gave teachers and tutors autonomy on deciding which of the available resources could meet their teaching style. Instructors with less experience in online and hybrid courses struggled somewhat to design their first offerings, for which they had to develop some teaching materials and adapt to new tools and a new routine. This was more of an issue for those teachers and instructors who started working online during the pandemic. Over time, the teachers received support from SENAI, including equipment and connectivity, and developed the necessary skills to provide higher-quality instruction.

Because of the 80-20 split (80 per cent distance learning and 20 per cent in-person learning), tutors offering the online course were not necessarily the same as those proctoring the practical in-person in the classroom or lab environment. This posed another practical challenge, in that online tutors had to create a face-to-face lesson plan the face-to-face tutors would need to execute to align with online course content. Alignment meetings between tutors determined what kind of material and resources the school possessed, and adapted content accordingly.

When asked how they felt when transitioning to hybrid teaching, most teachers evoked fear, anxiety and uncertainty. Instead of looking for trained tutors in the market, most institutions trained the teachers of the onsite courses as online tutors, providing semi-annual as well as sporadic training over the course of a month when needed. At the beginning of each semester, it was common for SENAI to create a pedagogical week, during which tutors were trained (usually at night) on two-and-a-half to three-hour courses]. Additionally, one of the senior tutors developed 'how-to' video tutorials to help other tutors and students navigate the learning platform.

SENAI also offered training to improve teachers' digital fluency, one of the main challenges arising from the 'teacher-turned-tutor' strategy. Faced with high resistance from faculty members owing to fear or ignorance, SENAI identified 'early adopters' who took the first step and showed others there were significant benefits to be gained from adopting the technologies. These trainers/tutors became 'multipliers' by expanding take-up, which also led to mentoring groups that supported and reassured others during the transition.

Several courses used innovative technologies (AI/ VR) with simulations, as well as all the back-end technologies, to support teaching and learning. As in other LMICs, students' limited access to the necessary equipment, internet connectivity and the course content was a hindrance, especially in the less industrialized states. SENAI offered some support in response: courses and online lessons were accessible via mobile phones or computer rooms, with no additional cost to access a specific platform or simulator; students simply paid for data. This support has also improved over time, as more open-source and less data-heavy apps are being developed and used.

Students highly valued the courses' flexibility and relevance. Although initially they felt uncomfortable owing to low digital fluency, tutors provided a lot of support, as did another facilitator when needed. WhatsApp was the default communication platform, but some participants could not access high-data videos or simulations on their 'old and buggy smartphone', heading to campus in such cases. Students appreciated the opportunity to view lessons again afterwards as part of self-learning. Having overcome the initial stress, they registered for other SENAI courses.

SENAI data revealed that students in hybrid distance learning differed from students enrolled in face-to-face courses. Initially, students in semi-face-to-face courses tended to be older; they often worked while taking the course, had to study at night, or did not have time to go to school every day. Over time, however, young people became interested. Thus, DX/ expanded both access and opportunities for people to take the courses.

3.1.3 Key takeaways: Brazil

Technical and technological

SENAI managed the technical and technological level of the digital transformation in TVET framework and solved problems over time:

- Administrative and managerial processes for creating and offering the online/hybrid courses started strong and improved.
- Instructors were provided with equipment and connectivity.
- SENAI supported instructors in acquiring general digital skills and using better teaching tools.
- Students were supported in obtaining access/ connectivity, as well as using the online tools.

Curriculum and qualifications

SENAI started the programme based on its previous experience of competency-based curricula for in-person traditional TVET courses, then used existing programmes to create online and hybrid courses based on the standardized processes. Areas were prioritized based on industry and learner needs. According to the head of the programme, needs were determined through 'prospective studies of technological foresight based on how technologies would be used in the next five to ten years, and also on the real demand of the productive sector.'

The next steps involved designing the curriculum, planning the course, developing teaching plans, offering online lessons, virtualizing textbooks, and later identifying and developing supporting materials and resources such as teaching kits and reference simulators. Once this was all in place, teachers/lecturers/trainers/tutors were offered intensive training programmes on the course content and delivery. Later, a follow-up evaluation assessed both the impact information (i.e. student employability) and students' overall satisfaction with the course content and delivery. Impressively, this process resulted in 70 technical courses, 233 certifications and 1,318 textbooks.

Teaching and learning

The programme's online and hybrid courses use many different strategies. The primary mode of delivery is hybrid, or 'semi-face-to-face,' comprised of 80 per cent distance learning and 20 per cent face-to-face learning. This does present a challenge; due to this split, tutors offering the online course are not necessarily the same as those overseeing the practical hands-on proctored sessions. This means that online tutors must create face-to-face lesson plans that the face-to-face tutors will execute to align with what is being taught in the online course. To this end, alignment meetings between tutors determine what materials and resources the school possesses, to adapt the courses according to the school's resources. Instructors received support to use more effective practices. For instance, to prepare the teaching staff for distance learning, the teachers of the onsite courses are trained as tutors, as opposed to the institution looking for trained tutors on the market. This is done through semi-annual training and sporadic training during a month as needed. Students, on the other hand, received support from tutors and other facilitators when needed, using WhatsApp groups to communicate.

Sustainability and resilience

This transformation was underpinned by a focus on organizational culture first. Digital transformation was implemented as a 'culture movement' aiming to 'change people's mindset', followed by a deeper understanding of digital transformation in TVET that also involved changing the teaching and learning process itself. The programme restructured traditional processes by incorporating technology, then improving and enhancing the teaching learning process. Results from students' evaluations show better learning results in several programme areas, and teachers were more likely to better connect theory and practice using digital tools.

3.2. India

3.2.1 Country context: India

With almost 40 per cent of the national population aged between 13 and 35, India is widely recognized as having the largest youth population in the world (ILO, n.d.). According to Grant Thornton (2020), the labour force in India is expected to grow by 32 per cent over the next 20 years, and there is a push to enhance the skills and employability of the workforce to ensure that India's demographic dividend[28] is an asset for the country. A key imperative for India is transforming 'the large labour pool into an adaptable, flexible and analytical skilled workforce who are responsive to the changing global needs and environment' (Kumar and Kaur, 2022).

At the same time, propelled by both the public and private sector, India is 'digitizing activities at a faster pace than many mature and emerging economies' (McKinsey Global Institute, 2019, p. 1), Spurring these digitization efforts is the 'Digital India' programme. Launched in 2015 by the Government of India (GoI) to digitally empower India and make it a knowledge-based economy, Digital India is an umbrella programme aiming to bridge the digital divide by ensuring digital access, digital inclusion and digital empowerment to

28. 'Demographic dividend' is the growth in an economy as a result of declining fertility and mortality rates. Low birth rates and low death rates boosts the working population's productivity as resources are freed up and invested elsewhere in the economy. *Source:* https://www.investopedia.com/terms/d/demographic-dividend.asp

create investment and employment opportunities, and digital technological capabilities in India (Ministry of Electronics and IT, 2021).

The successful penetration of high-speed internet service through the GoI's 'Digital India' mission facilitated learning through auto-paced and self-paced training modules in the most remote corners of the country, and enabled various digital interventions in the TVET landscape at all levels: (i) systemic (digital schemes and country-wide integrated digital skills platform); (ii) pedagogical (classrooms without walls; interactive, self- and auto-paced digital training through virtual, offline or blended models); (iii) curriculum (physical, digital and 'phygital' courseware and learning modules, depending on job role and sector); and (iv) technical (digital literacy and skills).

The following are the most relevant digital transformation in TVET interventions in TVETs in India:

- 'Skill India Digital' (SID) is a digitization effort of the Ministry of Skill Development and Entrepreneurship, which aims to facilitate the objectives of the 'Skill India Mission' (SIM) to upskill Indian youth to enhance livelihood opportunities and cater to industry-specific demand-supply gaps and labour shortages.
- The 'Hub and Spoke Model of Vocational Education' is an effort of the Ministry of Education under the *Samagra Shiksha Abhiyan* (Holistic Education Campaign, in Hindi), a pan-India government funded scheme to vocationalize education and support teacher-training institutions whereby the 'hub' school infrastructure and facilities can be used by the 'spoke' school students for VET.
- *Kaushal Mart* of the National Skill Development Corporation (NSDC) is an online skilling resource marketplace that aggregates skilling resources and reference materials to bridge the demand-supply gap.
- *Kaushal e-Pustakalaya* is an ebook reader application of the NSDC that provides readers with easy access to digital books in the sector and trade of their choice.
- *Bharat Skills* is a central skill repository of the Directorate General of Training that provides people with course material, videos, a National Skills Qualification Framework (NSQF) curriculum, a question bank, mock tests, etc. by clicking on the course of their choice.
- *Pradhan Mantri Kaushal Vikas Yojana (PMKVY)*, the prime minister's Skill Development *Scheme*, offers digital learning resources to PMKVY trainees covering their chosen job role in all sectors. The resources, which are provided by the NSDC, are self-paced, multilingual and can be accessed anytime, from anywhere.
- *Kaushal Panjee* (skill register) and *Kaushal Aapti* (psychometric skill and personality test) are being offered by the Ministry of Rural Development (MoRD) through *Deen Dayal Upadhyaya Grameen Kaushalya Yojana* (DDU-GKY) to help rural youth decide on their career paths.
- 'Start-Up Village Entrepreneurship Programme' (SVEP) was started by the MoRD as part of the National Rural Livelihoods Mission to promote village entrepreneurship through digital means.

These skill-development programmes and policy interventions are implemented by the NSDC under the aegis of the MSDE. Interventions focus on access and scalability across difficult terrains and varied socio-cultural and linguistic realms, and are grounded in the PMKVY, the flagship skill-development scheme of the GoI.

Table 8. Key statistics of TVET in India

KEY STATISTICS

Vocational education

Enrolment in secondary vocational, both sexes (number)

2.3 million

of which female (%)

16.6%

General education

Net Enrolment Rate, secondary education, male (%)

60.9%

for female students

62.4%

Education finance

Government expenditure on education (% total)

16.5%

on vocational education (% of total)

not available

TVET INSTITUTIONS AND RESPONSIBLE MINISTRY

Schools

252176 (2016)

Secondary and Senior Secondary

Ministry of Human Resource Development

Polytechnics

3867 (2016)

Diploma

Ministry of Human Resource Development

Industrial Training Institutes

14312 (2016)

National Trade Certificate

Ministry of Skill Development and Entrepreneurship

Source: UNESCO-UNEVOC Country Profile (UNEVOC, 2022b).

3.2.2 Case study: India

This case study focused on the scale and use of technology-enabled solutions in India, notably in the textile and welding sectors, where more innovative technology-driven solutions are being used. Launched in 2015 by the GoI, SID was identified as a prime example of digital transformation in TVET. SID was established to support the development of the country's workforce skills.

The GoI launched SIM in 2015 to empower Indian youth by enhancing their employability and entrepreneurial skills. SIM seeks to address the country's skill gaps and strengthen the framework of VET by supporting short-term, long-term and apprenticeship training; skill development and entrepreneurship; and some other skill programmes emanating from other ministries (GoI, 2021).

As part of Skill India, SID was established to pursue a trainee-centric and market-led skilling model. SID is a digital platform that provides demand-driven skilling programmes, in association with Indian industry and/or according to international requirements. Critical components include the digitization of courseware and teaching methodologies, for example, the provision of online videos and app-based learning and training delivery; secure business information management for registrations, assessments and certifications; and thorough onboarding of stakeholders, including project management partners and awarding, assessment and certification bodies. SID is accessed by multiple stakeholders and houses information on trainees, trainers, training providers, Sector Skill Councils and employers.

SID presents a unique integration of the mainstream and vocational education system, a vision of India's National Education Policy 2020 with its unified National Credit Framework system. It implements the 'vocationalization' of school education under the *Samagra Shiksha Abhiyan*,

with the Department of School Education and Literacy as its implementing agency. Through this effort, vocational courses compliant with the NSQF are offered at the senior secondary school level (grades 9 to 12).

The following features of SID are important to understand the penetration levels of digital transformation in India:

- SID is an inclusive industry-led, learner-centric framework that provides an intuitive learning interface, along with an AI-based course recommendation engine, for those in school/employment or those seeking job/apprenticeship opportunities.
- It provides learners with a wide array of options (for education, skilling, upskilling, reskilling and lifelong learning), in addition to online counselling, training in entrepreneurship skills and mentorship services.
- Earn-while-you-learn models, alumni services, job exchanges and course financing options are also made available to the candidates according to their real-time, geotagged location.
- SID also provides every citizen with secure profiling (a digitally verified credentials system) through a consent-based credential-sharing framework featuring proof of education, skills, employment and reputation.

In the context of efforts to streamline processes, systems and data, digital transformation in TVET initiatives within TVET in India include several platforms. The Skill Development Management System (SDMS) was a pioneer effort in this regard in the mid-2010s: it housed business tools required to operationalize skilling programmes on the ground, as well as real-time data management, including on courses offered; enrolments; training and certification records; employed candidates; ongoing batch details; and the registration of trainees, trainers, assessors, awarding bodies, training providers and training institutes.

With the advancement of technology, learnings from this database management system and the increasing requirements of a holistic digital platform, the SDMS was transitioned into the Skill India Portal (SIP) around 2017–2018. SIP is an integrated digital skill-development platform which was then an assembly of activities managed by the NSDC. It ran online candidate-training provider registrations; the onboarding of trainers, assessors, subject-matter experts, awarding and assessment bodies; online profile credentialing; and online courses offered through the eSkill India portal. The eSkill India portal is an e-learning aggregator platform of the NSDC that hosts multilingual courses with interactive video-based learning, mapped across all sectors. Trainees can register through their mobile numbers to access a user-friendly search engine that enables navigation to the course of choice through an aggregated catalogue.

At the curriculum level, various TVETs and skilling institutions are mandated to train, upskill and reskill with new knowledge and capacities that meet industry standards and new developments. In TVET specifically, the schemes described below are currently being implemented. Modules on digital and financial literacy and soft skills have been delivered through online, offline and blended modes of training. Online, portal-based design and development of curricula has been managed under the aegis of MSDE, in alignment with regulatory and awarding bodies on the SIP, through a maker-checker mechanism to release the best modules.

Skill-Box (kit-based) learning provision through several private-sector start-ups has been a novel pursuit to enable a remotely proctored class-like scenario, whereby the students acquire hands-on training at their own premises. For example, for an electrician's course, a kit with all the essential electrical supplies would be provided to enable the trainee to construct a circuit for lighting a bulb. The skill boxes are developed subject to sectoral, employer and market demands, as well as the popularity of the course(s) among prospective students. They are subsequently distributed to the trainees enrolled in the selected courses. In addition to government support, the private training providers seek funds from firms as part of their corporate social responsibility duties under the Companies Act (which allows corporations to assign a share of their annual profit to development activities). Training providers generally use this funding to deliver skill training that is relevant to the market and to funding organizations that are ready to take in these trainees as apprentices or employees. This initiative is scalable and replicable across geographies by virtue of its online tutoring and proctoring mechanisms. The GoI is currently deliberating on facilitating this training delivery mechanism at the state and district levels, and at both the school and vocational education levels, to increase the project's reach and support youth employment in the most remote areas of the country through remote self-learning.

In another example, the 'Digital India' campaign by the Ministry of Electronics and Information Technology has supported the use of DigiBunai computer-aided design (CAD) software for loom weaving in the textile sector. This has enabled training in intricate textile design using CAD software, with the designs digitally fed into the looms through USBs or other tools. Importantly, trainers and assessors were trained in the software prior to the training being delivered to students.

The digital credentialing of trainees takes place through an identification number-based attendance system called AEBAS, which has every citizen's unique identity number and iris scan. Sectoral/industry orientation videos are hosted by the NSDC in vernacular languages, giving insights and awareness to trainees on career growth prospects and livelihood opportunities through active involvement and participation from the sector skill councils.

The 'Skill Saathi' career counselling campaign was launched by the NSDC under the aegis of the Ministry of Skill Development and Entrepreneurship, which provided the funds. The goal was to create or facilitate career awareness among Indian youth, to enable them to make better career choices based on their skills and aptitude. In addition to conducting awareness campaigns in schools and universities, an online omnichannel platform was created to further the campaign's mission of preparing young people to pursue career choices better suited to their psychometric profiling and aptitude. The platform registered students interested in career counselling, and informed them on geo-proximate upcoming counselling batches they could attend. Private implementing counselling organizations provided counselling sessions, their disbursement details, and performance reviews through geotagged and time-stamped monitoring and evaluation. During the counselling sessions, industry experts were called on to provide insights and encourage students to pursue various career paths, also connecting them with employer organizations looking for candidates who matched their job specifications.

Smart Classes, virtual, AR/VR-based learning modules and simulation-based exercises have always been part of Indian skill-building and training delivery practices – perhaps more so post-COVID, although not in all sectors. Other initiatives include 'bagless' internship days,[29] introduced under the *Samagra Shiksha Abhiyan*. This innovative pedagogical component sustains the interest levels of trainee students, including through industry study visits where students are not required to bring their bags, coursework, books and learning materials. Apprenticeship-embedded, degree-granting channels of learning include both apprenticeship and job as part of the learner's journey. The Unified Curriculum Framework (which integrates educational and vocational curricula) and National Credit Framework (whereby the Academic Bank of Credits acts as the central repository for credits earned by the learner) have allowed a smooth incorporation of vocational streams into the mainstream education space. As the objectives of the Abhiyan have a long-term orientation towards vocationalizing education, it spans across the entire country to cater to all schools at secondary and senior secondary levels in both rural and urban areas.

The government's National Apprenticeship Promotion Scheme (NAPS) provides financial support to industry establishments that undertake/encourage apprenticeship training. It also offers a dedicated NAPS portal where apprentices and employer organizations can register for apprenticeship opportunities and courses customized to industry requirements. The portal has a three-pronged approach of catering to: (i)apprentices/students (by acting as a platform for registering their profiles for job opportunities and courses); (ii) employer organizations (which can register to find suitable candidates for their jobs and also create customized courses according to their industry requirements); and (iii) *Pradhan Mantri National Apprenticeship Mela* (PMNAM), which are online and offline job fairs managed by the Directorate General of training under the aegis of MSDE.

Kaushal Mahotsav is another job fair held widely across the country by the NSDC to connect candidates interested in skilling and job opportunities with employers. These fairs are held at periodic intervals, both offline and online, with both students and employers registering online through a dedicated portal. Candidates interested in international careers also receive counselling at dedicated counters within the fair. In that regards, 'International Kaushal Mahotsav' job fairs are a specialized practice where candidates and employers register for: (i) counselling on international job opportunities and organizational matching; (ii)

29. 'Bagless' refers to days when students do not need to carry coursework (e.g. bookbags or similar) when they visit industries.

online interviews for available job opportunities; and (iii) finally, offer letters, enabling candidates to realize their potential and meet their international career aspirations.

Digital transformation in TVET within TVET classrooms in India has largely focused on blending learning, whereby multimedia technologies for interactive learning, online learning portals, virtual and simulation labs have supplemented and enhanced learning. However, major innovations in the classroom, like AR, VR or extended VR, are only available in the well-resourced TVET skilling institutions.

The key offerings of digital transformation in TVET in India, as noted by respondents, include:

- Enhanced user experience: digital transformation in TVET helps organizations deliver better user experiences through the use of digital technologies such as AI (bots), automation and analytics.
- Improved efficiency and productivity: digital transformation in TVET can help organizations automate and streamline processes, reducing manual labour and increasing productivity.
- Better decision-making: digital transformation in TVET can provide organizations with access to new forms of data and insights, which can inform better decision-making.
- Accessibility: digital transformation in TVET helps mitigate the geographical and physical limitations of outreach.

The unique biometric identifier was cited as an innovation at the system level, which responded to the challenge of poor attendance and multi-reporting between the various schemes being implemented owing to the 'lack of convergence between the multitude of schemes'.

As digital transformation hoped to supplement and enhance the conventional teaching methodology and TVET activities, the Indian government has taken steps to pursue a system-wide integration of all TVET, educational and skilling platforms under one umbrella, and in alignment with all line ministries and government department, under the SID mission. It offers the innovative concept of connecting schooling, skilling, apprenticeship and employment opportunities and activities on one platform.

This convergence of skill-building/TVET schemes and courses is being pursued by multiple government ministries to design and implement targeted programmes for youth, including:

- skill development and entrepreneurship (skill-building, counselling and apprenticeship, employment and entrepreneurial pursuits)
- education (student registration, vocational schools and skill hubs)
- external affairs (international workforce mobility)
- labour and employment (LMIS)
- Small, medium and micro-enterprises (entrepreneurship)
- women and child development (entrepreneurial learning, education and welfare)

All these skill-development initiatives play a significant role in developing India's human capital. However, they must also promote lifelong opportunities, educating and skill-building in a manner that leads to more sustainable societies and greener economies. As such, vocational education reforms are the most important tool in realizing SDG 2030 and the SDGs. Indian industry is spearheading several environmentally friendly technologies, with active advocates imparting skills to prepare youth for fast-changing sustainable and renewable technologies.

Several TVET courses have been introduced to prepare a ready workforce and youth for the future of work and future-oriented job roles, and awareness of environmental issues is considered a key priority in this respect. In 2022, for example, FunFirst, a private limited company and a funded partner of the NSDC which focuses on skill-building and development in the electronics and telecom sectors, introduced greening technologies[30] into its curricula to maintain and repair energy-efficient air conditioners[31] once sponsorship and an industry partner was on board. To meet their goal of developing skills for high-end, market-driven jobs for all, several private start-ups

30. Also known as sustainable technology, it is environmentally friendly technology that considers both the short- and long-term impact something has on the environment.
31. The cooling sector in India is considered a large source of both direct and indirect emissions of potent greenhouse gases (Ravindran, Garg and Bhasin, 2022).

and training providers have initiated courses like a 'heating, ventilation and air conditioning' programme by sourcing sponsorships and industry partners willing to offer internships/apprenticeships that provide on-the-job training/exposure and job opportunities at the employer's premises.

3.2.3 Key takeaways: India

Technical and technological

SIP appears to be the main digital transformation in TVET effort being implemented by TVET and skill-building institutions to promote digital transformation and make it easier for individuals to obtain information, find training centres using geolocation, access courses and curricula, register for programmes and connect with employers. This portal is necessary as there are several interventions running simultaneously, all supporting two national key initiatives: Skill India *and* Digital India. The key challenge the portal seeks to mitigate is the effective integration of technology and data with existing systems and databases.

Even with this portal, however, an important issue for India's digital transformation in TVET is the demand and supply of informal labourers in the wake of the digital transformation, since they are not technologically adept enough to create a 'skill portfolio'.

To tackle these challenges, the NSDC and its member organizations are adopting an aggressive partnership approach with employers and industry to better tailor digital transformation efforts to their needs. Finding the right technology that is easily accessible and user-friendly is also crucial. It is important to note that confronting these challenges takes time and effort, and is not a one-time solution. It requires continuously monitoring, fine-tuning and updating systems and processes to match the evolving needs of industry and employers.

Curriculum and qualifications

In keeping with Digital India, compulsory digital literacy modules lasting 20–30 hours are being inserted into the qualification packs of the curriculum across the spectrum of trades to ensure that students possess the basic skills necessary to learn, live and work in an increasingly digital society.

Digital transformation in TVET efforts in India have also seen faster curriculum adaptation, as new materials can easily be developed and added to the curriculum in keeping with new developments in industry. Digital transformation in TVET is also improving the quality of the curriculum, not only by better meeting industry needs, but also by becoming more learner-centric.

Teaching and learning

In the main, most TVETs and skilling service providers in India use multimedia technology for interactive learning or online learning portals, especially following COVID-19. India's TVET institutions mostly rely on the following modalities:

- Online and blended learning methods using digital applications. These includes online lessons which can be recorded (or pre-recorded and accessed later by learners as self-learning modules), as well as other online resources such as videos, materials and demos.
- Simulations that foster experiential learning in tandem with online and blended learning methods are cost-effective and provide hands-on experience safely.
- Practical and project-based learning. Technology enables students to apply the skills they have learned to real-world scenarios and projects, and also allows them to work with industry partners in situations where a product or service could be used.
- Skill boxes are cost-effective, and easily scalable and adaptable to different industries.
- 'Bagless' internship days[32] allow students to go on industry study visits where they gain exposure and hands-on experience, including knowledge enhancement, generic skills and domain skills, in their area of concentration.
- VR and AR teaching is also being explored in India, but is not widespread and is usually localized to the more resourced institutions, which target a small minority of the Indian population who can afford to pay the fees.

32. See footnote 17

- The more personalized learning experience, online assessment and analytics allow candidates to receive real-time feedback on their performance, followed eventually with an individualized course of correction.

However, as highlighted in the literature and echoed by the other case studies in this research, the success and efficacy of blended learning requires high-quality, ongoing professional development opportunities.

Sustainability and resilience

This case study showed innovative solutions and policies introduced by the GoI. The digital transformation of TVET in India is widespread and multiple schemes and programmes are being implemented under the aegis of Skills India and Digital India but no single institution is implementing all of them. There is still more to do to prepare individuals for the skills of tomorrow, especially in countries like India where a large proportion of the population is below the poverty line. Although considered important, developing sustainable societies is not always a top priority. Vocational education reforms are the most important tool in realizing the SDGs, as set out for 2030.[33] However, unless environmentally friendly technologies are spearheaded by industry and actively championed by the government, TVET institutions often do not see sustainability and green economies as key priorities for the immediate future.

3.3. Jamaica

3.3.1 Country context: Jamaica

In the Caribbean region, TVETs' share of enrolment grew steadily between 2002 and 2019, from 14.5 per cent to 22.4 per cent (UNESCO, 2022c). This period saw a general integration of the competency-based approach into curriculum frameworks across the Latin American and Caribbean region, leading to the development of more general competencies in four areas: 1) technical or occupational competence, 2) academic competence, 3) pedagogical or professional competence, and 4) personal qualities and attitudinal competence. At the same time, existing branches and specialties have been readapted according to technological changes and new production demands (UNESCO, 2022c). More females than males were certified in 2022, with women accounting for 64 per cent of certified individuals.[34]

The challenges faced by TVET education in the Latin American and Caribbean region include slow economic growth, poor income distribution, educational inequality, high rates of informal employment and high rates of unemployment. As much as 70 per cent of the labour force has not received formal training, and increasing workforce migration rates have also had a significant impact on Jamaica's TVET policies, which centre on occupational and workplace skills (UNESCO-UNEVOC, 2012). The current knowledge-based, technology-driven world demands that the Jamaican education system leverage technology to equip citizens with literacy, numeracy and ICT skills, as well as critical thinking, complex communication, innovation, and social and personal responsibility. In Jamaica, as elsewhere in the world, the skill demands of today's labour market have created a need for further educational opportunities and the reconceptualization of learning, especially in ICT-related areas (Government of Jamaica, Ministry of Education and Youth, 2022).

In 2006, the government began implementing recommendations from the National Education Task Force, including engaging teaching and learning with distance modalities; training teachers in using ICT; and providing internet access to all schools, using wireless technology if necessary. These recommendations aimed to improve the quality and equity of the education system; all public secondary schools, as well as 16 of 77 (approximately 21 per cent) of private schools, were equipped with technological devices and training to facilitate ICT-based teaching and learning. ICT use at the tertiary level is more advanced, but teacher-training institutions require further interventions to ensure adequate capacity-building (Government of Jamaica, Ministry of Education and Youth, 2022).

33. See the 17 SDGs.
34. See https://lmip.heart-nsta.org/ETI.aspx

Table 9. Key statistics of TVET in Jamaica

KEY STATISTICS

Vocational education	General education	Education finance
Enrolment in secondary vocational, both sexes (number)	Net Enrolment Rate, secondary education, male (%)	Government expenditure on education (% total)
376	71.7%	17.3%
of which female (%)	for female students	on vocational education (% of total)
42%	76.3%	not available

Source: UNESCO-UNEVOC Country Profile (UNEVOC, 2022d).

3.3.2 Case study: Jamaica

This case study focused on the digital integration of Jamaica's TVET education system. Participants in the research included representatives from the Human Employment and Resource Training Trust/National Training Agency (the HEART/NSTA Trust), international organizations, and representatives at both the administration and lecturer levels of TVETs.

The Jamaican government has signalled its intention to pursue the digital transformation of its systems and the Jamaican economy through various policy initiatives, including the ICT Sector Plan, the ICT Strategy, the National Strategy to Develop Jamaica's Global Digital Services Sector: 2021–2025 and the ICT in Education Strategy. Policy frameworks are therefore in place regarding both overarching national goals and details such as the delivery of content for TVET educators, and policy goals include making ICT qualifications a core subject in schools. However, educators in Jamaica have a relative amount of autonomy about policy and strategy enactment.

The major government organizations involved in Jamaica's TVET system include:

- **The Ministry of Education and Youth**, which delivers TVET at secondary schools covering the following sectors: agriculture, business education, home economics, industrial education and visual arts. TVET provision in secondary schools is overseen by a technical and vocational education unit, which oversees the curriculum, work experience programmes and the 'Career Advancement Programme', a two-year vocational education programme established to provide qualification opportunities to learners who complete secondary education without obtaining any formal certification.
- **The National Council on TVET,** which acts as a quality oversight body and regulator. The NCTVET is responsible for the National Qualifications Register, a central database of information on qualifications, training, assessment and certification relevant to facilitators, learners, employers and other key stakeholders in the Jamaican TVET system. It is also charged with developing competency standards and assessment instruments; providing certification to individuals and accreditation to TVET institutions, programmes and registered training organizations; and ensuring that certified instructors within the TVET system are competent (UNESCO-UNEVOC, 2012).
- **The Human Employment and Resource Training Trust/National Service Training Agency Trust (HEART/NSTA Trust or HEART).** Funded by a national skill levy,[35] HEART has acted as a human-capital development agency in Jamaica for more than a decade and is also active as part of the Caribbean Community (CARICOM). HEART focuses on practical, competency-based training that enables trainees to transition into workplace scenarios. On a practical level, this provides trainees with institutional-based training programmes through 'on-the-job' training approaches. Services include assessment, training

35. In this case, a 3 per cent payroll tax on qualifying private sector firms.

and certification; work experience; volunteering and mentorship opportunities; and professional development services. Although 48 per cent of its training programmes are geared towards TVET students (HEART/NSTA TRUST, 2021), HEART also supports adult learning, business development and entrepreneurship, digital literacy, and a 'Tech$ense' programme aimed at enhancing citizens' financial and technical skills. HEART also offers free online learning programmes, including CISCO and Microsoft courses.[36] Finally, it provides digital access and training to the general population through parish offices and partnerships. In addition to 28 HEART institutions, the organization boasts over 80 community training initiatives.[37]

All these institutions have roles to play in Jamaica's digital transformation. At the Higher College of Education and Technology in Montego Bay, efforts to digitize data points and use Moodle have been ongoing since 2005, and the institution has striven to become 'paper-free' in its administration. Moodle is used to control registration, access classes and content, and record and review class and examination marks. Remote teaching was offered for the first time in 2009, resulting in a diploma in GIS. To develop the content, the institution partnered with CISCO, which also provided access to its Webex videoconferencing software. The college now combines remote and face-to-face courses, but still conducts most of its training face-to-face. Instructors are nevertheless capable of delivering fully online courses and were able to transition swiftly to fully remote operations during the COVID-19 pandemic. On the other hand, a large part of the population, as well as TVET instructors, have only basic literacies. For example, Jamaican officials discovered from community surveys that 'many people think Facebook is the internet'. They noted that supporting teachers entailed teaching them the basics, such as learning how to create an email, thus complicating the vision of universal digital literacy in TVETs. Many teachers are nervous or in some cases, uninterested in digitally upskilling themselves. Additionally, some of the more prevalent engagements with technology in the country are predicated on illegal activities such as scamming, adding to the general hesitance to engage.

Jamaica also engages in international partnerships to support digital transformation and other national objectives, including the Commonwealth of Learning (COL), an intergovernmental organization that focuses on enabling open distance learning in education. Through HEART, COL has been involved in capacity-building and resource development for TVET systems, along with other related Caribbean-based initiatives at both the national and institutional levels. COL has also worked closely with the Ministry of Education and Youth to develop strategies for building resilience.

Although Jamaican TVET stakeholders at both the national and institutional levels recognize the importance of digital skills and digital integration, community members are starting from an extremely low baseline of digital skills. Core digital transformation in TVET initiatives in Jamaica include the delivery of blended or online courses using the Moodle LMS, and the development of a digitally enhanced labour-market intelligence system. At the institutional level, TVETs in Jamaica are integrating student management systems schoolwide to manage functions including applications, payment features, classwork and assessments, recording and accessing grades, and certifications and digital badges. HEART's Learner Resources Unit, comprised of a combination of internal and external sources, is responsible for creating the curriculum and populating the online platforms.

3.3.3 Key takeaways: Jamaica

Technical and technological

A primary challenge in providing the necessary infrastructure is poor connectivity, especially in rural areas. Some participants place their hopes in recent innovations, such as Starlink, to improve connectivity in particularly rural areas that cabling and fibre infrastructure cannot currently reach.

Two common platforms for TVET education in Jamaica are Webex, a videoconferencing software by CISCO, and Moodle, an LMS system used and promoted by HEART to facilitate student training and e-learning. HEART stakeholders indicated that the next step in the adoption journey is to create an end-to-end system that tracks progress from admission to the credential or qualification.

COVID-19 has been a primary leverage point to digitalize the TVET system in Jamaica. As elsewhere, distance/remote learning in the country became the main mode of instruction during the COVID-19 pandemic. With this new dispensation, each educator

36. See https://freeopenonlinetraining.heart-nsta.org/
37. See https://www.heart-nsta.org/our-story/

and student must be equipped with a technological device to effectively operate within a digitally advanced teaching and learning space (Government of Jamaica, Ministry of Education and Youth, 2022).

Although efforts to provide access to the infrastructure required for ICTs and ICT training have been ongoing for many years, including through funding for infrastructure and the provision of devices to students, stakeholders still feel the need for more support and particularly industry partnerships, to fully develop the potential of ICTs in Jamaican TVET education.

Curriculum and qualifications

One of the main policy goals of Jamaica is to grow the digital economy. To support this goal, ICT qualifications have been integrated as a core subject in basic education and TVETs alike. The Jamaican curriculum has sought to keep pace with industry developments, including by establishing colleges and courses in digital topics. Yet despite efforts, stakeholders indicated a dramatic difference between the skills of graduates and the needs of industry. They opined that closer collaboration with industry in programme delivery could be a solution, to ensure that 'the equipment and methodologies used in TVETs will be those of industry'. Ongoing partnerships of Jamaican TVETs with various German companies are one example of such collaboration.

The Higher College of Education and Technology in Montego Bay was one of the first schools to embrace Moodle in 2005 as a tool to control registration, class access, grades and content. Online programmes in digital skills were initiated through partnerships with CISCO, which also provided access to Webex. Additionally, using the Microsoft Suite, the college created makeshift MOOCs during the COVID-19 period.

Teaching and learning

The shift to remote learning during COVID-19 made enrolment possible for many more students, with one course drawing over 1,000 learners. Teachers and trainers were able to leverage common tools such as Microsoft Office Suite, as well as industry courses available online to create new types of courses. Lecturers also recorded their lectures, ensuring remote access within 24 hours of its presentation. Cost savings were also an important aspect of remote engagement and learning, particularly thanks to simulations. One stakeholder explained how digital transformation in TVET can simply make teaching cheaper, as it reduces the need to 'go out and buy training materials for a class of 50 people, which could cost a couple million dollars'.

Given the benefits, participants in this case study agreed that TVET teachers and administrators must now possess all basic ICT literacies, as well as the ability to navigate different technologies and modes of instruction. For the educators, policy and strategy enactment has been supported by nationally financed workshops aimed at developing their online competencies and delivery skills.

Some TVET institutions (particularly those that already focus on delivering digital skill programmes) were 'ahead of the curve,' with innovations such as blended or online learning programmes already in place. Many other lecturers, however, engaged in blended learning for the first time during the COVID-19 pandemic, some so unsuccessfully that their interventions were driving communities to hand out paper copies of assignments and classwork.

Integrating digital technologies requires shifts in pedagogy, but the required changes mentioned by participants are not closely linked to the digression from didactic teaching methodologies. Their primary concerns, particularly at the ground level, were to ensure that students were engaging in and absorbing the material through videoconferencing platforms, and were also not cheating on remote examinations, activities or assignments.

Additional pedagogical challenges included some teachers' lack of charisma and inability to keep the material interesting for students. One important point was that remote teaching requires more effort from teachers compared to face-to-face teaching, which involves less talking by the teacher and more interaction with the class. As a HEART senior instructor pointed out, many students struggle with the lack of constructivism associated with online teaching and also struggle to navigate online platforms, making it harder to encourage participation.

Sustainability and resilience

Despite the challenges, stakeholders agree on the importance of persevering and moving forward with digital transformation. 'As the world changes, we cannot remain the same', they noted, adding that 'if you teach your students the way you have been taught, you are robbing them of a brighter tomorrow.' There is a perception that many young people prefer digital

formatting and delivery and enjoy the benefits of online courses, including the expanded reach of TVET institutions in the country's rural areas. The onset of the COVID-19 pandemic also contributed to more internet investment in Jamaica in partnership with Starlink, advancing digital transformation in TVET.

The 2022–2023 period is likened with 1981, the year the Apple computer was first introduced and increased digitization throughout society. HEART takes the lead in this aspect for Jamaica, in that it is involved in a variety of partnerships to facilitate the delivery of digital training for the general population through programmes and interventions based on the recipient's basic reading, writing and mathematical skills.

One additional intervention of HEART is the Labour Market Intelligence Programme (LMIP),[38] which was created to identify current and future jobs and skill gaps, align training programmes and skills needs, provide resources to assist individuals in making career and skill-development decisions, and enable stakeholders across the system to access information about the skills available in the labour market (which also is seen as supporting investor and entrepreneur confidence in the country). The LMIP is still under development but already provides information on labour-force participation, education and training certifications, and awarded qualifications. HEART also conducts annual labour-market surveys with various stakeholders and employers to collect feedback on employed trainees and how TVETs could improve their training.

3.4. Kenya

3.4.1 Country context: Kenya

Kenya is one of the leading countries in Africa in terms of applying digital transformation to help citizens transition to the modern age. Sustainability is the goal of transforming countries to respond to a new age of inclusive economies and centred on human well-being, underpinned by the SDGs, of which Kenya is a signatory (Onyango and Ondiek, 2021). Digitization and digitalization contribute to this goal by extending access to services for citizens, thereby fostering an inclusive economy.

An important consideration is those on the margins of the mainstream economy, as the government recognized that a large share of Kenyans derive their livelihood from the informal economy. The introduction of M-PESA to the Kenyan financial sector is one government-led intervention that made it possible for Kenyans from all walks of life to gain access to the mobile payment economy through mobile devices (Banga and te Velde, 2018). M-PESA is essentially a cash, digital and credit card that facilitates micropayments for everyday transactions, such as buying candy, paying for school fees and other digital transactions (ILO, 2020a). The system had to consider the informal nature of the Kenyan economy and adapt its service offering, leading to its successful application . Kenya's TVET system can draw lessons from the flexibility of this government-run system (ILO, 2020a).

The Kenyan government is currently engaged in projects to develop databases that will facilitate data-sharing through portals that hold citizen data, including student information (Firestone et al., 2017). Once the databases are operational, they must be interoperable with all other systems storing student and employment data, creating an ecosystem that brings together work seekers and employers.

The vision of the government-run Huduma centres is that they will hold citizen information that is accessible with a unique ID, issued from birth or time of registration and valid until death. This system will be the central locus for information about every Kenyan citizen, without the need for numerous duplicate databases. An online service centre, aided by an electronic chip that holds all information and can be used within the East African Community (EAC) region, will enable Kenya to create a one-stop-shop for all civic services.[39] The implementation process highlighted the lack of infrastructure, electricity and connectivity that support digital transformation in TVET faced by some parts of the country, especially remote areas, as well as the challenges in accessing devices and the high cost of data that disproportionately affect already marginalized populations.

Work on improving the image of TVET in the country is already underway, but outcomes resulting in better job prospects should attract more young people to TVETs as a first-choice educational pathway, potentially leading to more investment being redirected into the system (Musyimi, 2021).

It is paramount for Kenya to develop a TVET system that can produce citizens who can interact with these interventions for the benefit of the wider economy.

38. https://lmip.heart-nsta.org/About.aspx
39. https://www.hudumanamba.go.ke

Table 10. Key statistics of TVET in Kenya

KEY STATISTICS

Vocational education

Enrolment in secondary vocational, both sexes (number)

15.7 thousand

of which female (%)

57.8%

General education

Net Enrolment Rate, secondary education, male (%)

49%

for female students

45.8%

Education finance

Government expenditure on education (% total)

19%

on vocational education (% of total)

not available

TVET INSTITUTIONS AND RESPONSIBLE MINISTRY

Technical Vocational Centres

850 (2018)

Ministry of Education/ State Department of Vocational & Technical Training

Technical Vocational Colleges

123 (2018)

Ministry of Education/ State Department of Vocational & Technical Training

National Polytechnics

11 (2018)

Ministry of Education/ State Department of Vocational & Technical Training

Source: UNESCO-UNEVOC Country Profile (UNEVOC, 2022c).

3.4.2 Case study: Kenya

Since 2007, Kenya has emerged as a leader in digitalization in sub-Saharan Africa thanks to the introduction of mobile money through Safaricom's M-PESA, but more importantly, by introducing legislation that created an enabling environment for digital transformation in TVET. The inclusion in 2006 of ICT as a development pillar in the government's '2030 Vision', followed by the introduction of high-speed internet in the country thanks to the installation of undersea fibre-optic cables in 2011, led to the launch of the Kenya Open Data Initiative that same year, which made government data freely available through a single online portal. The National Broadband Strategy of 2013 made subsidized broadband available for universities and technological hubs (Banga and te Velde, 2018). Although it does not mention TVET alongside universities with regard to subsidies for broadband access, it provides the foundation for TVETs to benefit from the country's broader initiatives and embark on a digital transformation. Kenyans often view the TVET system as a less preferred option to the academic stream of universities (Gretch and Camilleri, 2020). Most efforts at a basic level still focus on attempting to secure the proper infrastructure and enhance the training of trainers.

Kenya is currently using the 2019 ICT Strategy, a revision of the 2006 ICT Strategy, to guide developments in education. The 2019 strategy aims to create a knowledge society where technology plays a major role and e-learning is a major mode for delivering curriculum content. It recognizes the need to train teachers and enable them to facilitate this type of learning (Banga and te Velde, 2018). In an effort to modernize the type of training provided to teachers, in line with the digital transformation objective contained in policy documents, the Ministry of Education, Science and Technology has reviewed the teacher-training curriculum at the pre-service level, developed an in-service ICT teacher-training curriculum across all levels of education, and ensured that teachers and teacher educators at all levels of the education system are equipped to acquire their own ICT equipment under a 'one-device-per-teacher' policy (Barasa, 2021, p. 13). At the time of writing, information

regarding progress in achieving these policy goals was not available. While the Kenyan Ministry of Education Science and Technology's progress with respect to teacher training at all levels should be noted, it is important to emphasize that the impact of AI on VET trainer skills and curriculum needs can only be partially anticipated, as innovations in – and derived from – AI are rapidly changing skill needs, and therefore employer expectations. VET curriculum developers must remain aware of changing skill requirements on the shop floor and consider the consequences of new or different demands for VET lecturer teaching skills in relevant occupational environments.

This case study focused on an initiative overseen by the Kenya National Qualifications Authority (KNQA). In addition to managing the central register of qualifications, the KNQA is in the process of developing the Kenya National Learner Record Database (KNLRD) while also working on the development of the National Qualifications Management Information System, a set of interoperable databases and registers for the management of the Kenya National Qualifications Framework (KNQF) (African Continental Qualifications Framework [ACQF], Keevy et al., 2021). The registers and databases are meant to make it easier for different users to access information about qualifications in the country, leveraging the digitization of these records to create an efficient system.

The KNQA was established in 2015 to coordinate and harmonize all education in the country (Keevy et al, 2021). This was done in part by establishing the KNQF, which now has the task of the creating an 'accurate, reliable and robust database of all qualifications in the country that will allow for comparability, equation, recognition and information sharing of qualifications on a global scale'. The KNQA is the main body that advises the government regarding all qualifications awarded in the country while also working with other institutions that operate in the same educational space, including at the TVET level (ACQF, 2021). The authority's functions include developing a system for the assessment of national qualifications; and developing and reviewing the interrelationships and linkages across national qualifications, in consultation with stakeholders, relevant institutions and agencies.[40]

The country's National Education Sector Strategic Plan 2018–2022 shifts the focus of the education system towards CBET at the TVET level, affording an opportunity to ensure the digital transformation of the curriculum, teaching and training. In the 2016 *Education Sector Report*, TVET infrastructure (Republic of Kenya, 2012), as well as science and technology research were some of the key priority areas earmarked for funding (Barasa, 2021). This was good news for the sector, given that TVET has a history of challenges, including funding for infrastructure and equipment, and not just in Kenya. The intervention also features an element of sustainability by ensuring access and inclusivity for marginalized groups. In its efforts to ensure equity for all learners, the Ministry of Education aimed to implement the 'Laptops and Assistive Technology Plan for Learners with Special Needs' through the 'Digital Literacy Programme', including the 'provision of assistive technology and specialized laptops to assist visually impaired and physically disabled students in their learning; provision of laptops for visually impaired learners in secondary schools, TVET institutions and universities; and adaptation of digital content materials for learners with special needs' (Barasa, 2021, p. 16).

Challenges are bound to happen as interventions as implemented, and there was no exception here. Some notable challenges included (Barasa, 2021):

- battery failure for those relying on solar power
- high power bills
- a need for technical maintenance of facilities and provision of first-line support
- lack of internet connectivity
- lack of data on connectivity (making it difficult to map areas with connectivity needs)
- inconsistent connectivity (weak signal)
- destruction of telecommunication installations in areas prone to internal conflicts and border insurgencies
- theft of tablets and computers
- lack of secure storage for ICT equipment

The Kenyan TVET system has been a victim of poor marketing and is not the first choice for learners seeking to pursue further education and training, with university

40. http://www.knqa.go.ke/

education the desired goal for both learners and career advisors (Gretch and Camilleri, 2020). Of course, marketing alone is not responsible for the bad image of TVET in Kenya. Other factors include an outdated curriculum, poorly trained teachers and trainers, and the lack of supporting infrastructure and equipment that can keep pace with the needs of the labour market (Gretch and Camilleri, 2020; Muriuki and Dominic, 2022).

The Kenya labour market of the 21st century is a dynamic place characterized by rapid changes, driven by the advancement of technology. Such advances have created a situation where the training and supply of labour becomes more difficult for many countries. The need for TVET institutions to keep up with labour-market demands requires flexibility in how training providers approach policy, and in their ability to keep up with the infrastructure and equipment relevant to the labour market at any given point (Gretch and Camilleri, 2020; Muriuki and Dominic, 2022). Gretch and Camilleri (2020) note that TVET systems have not integrated mobile technology for voice calls and payments as a driver for their digital transformation. However, voice call and payment technologies have been promoted by VET programmes that support entrepreneurs and small business operators in reaching more clients and suppliers. Of course, the COVID-19 pandemic drove governments to implement this transformation out of necessity when lockdowns forced many – including students – to stay home.

Other initiatives promoting digital transformation within Kenya's TVET space include 8 technical institutions offering 'CISCO Networking Academy' programmes in computer repair and maintenance, enabled by 40 TVET institutions connected to the internet by the fibre-optic cables installed in 2011 (Barasa, 2021). Efforts continue with a partnership between Kenya and Germany's agency for international development GIZ involving three TVET institutions earmarked as centres of excellence which are working on a project to integrate ICT in the training of young people, also incorporating the German dual-system model (Barasa, 2021).

In terms of curriculum development, the KNQA is currently developing occupational and training standards in consultation with industry stakeholders to align with industry needs, including new digitalization requirements in the world of work. It is working with some of the other regulatory bodies in the system, such as the Kenya Institute for Curriculum Development and the TVET Curriculum Development and Certification Council, and various other institutions, such as universities and TVET institutions with a legal mandate to develop curricula in the country. One of the main institutions that work closely with the KNQA in managing Kenya's TVET is the Technical and Vocational Education and Training Authority (TVETA), established in 2013 to ensure quality in TVET (ACQF, 2021). The institution plays another important role in that diplomas and certificates offered by Kenyan universities must be approved by TVETA and the Commission for University Education (Keevy et al, 2021, p.102). The ICT Strategy outlines that Kenya aims to include ICT subjects in the curriculum at all levels of education in order to successfully develop human resources and guide KNQA at the policy level to drive digital transformation in TVET in the education sector (Ministry of Information, Communications and the Digital Economy, 2021).

The concept of 'sustainability' at the government level entails access and participation that can lead to a sustainable society. The ICT Strategy in support of the country's 'Vision 2030', for example, states that every Kenyan 'will be computer literate and able to profitably engage in the digital economy and earn a good living' (Ministry of Information, Communications and the Digital Economy, 2021, p. 33). In the quest for digital transformation in TVET in the education sector, the KNQA developed the National Qualifications Information Management System (NAQIMS) to manage national data pertaining to qualifications, recognizing these data were held by different institutions, creating discrepancies in the information obtained when other institutions tried to gather it for their own purposes. Thus, the information management system will solve many of the challenges facing the country when dealing with learner data. The KNQA is concurrently working on a learner database, the Kenya National Learners Record Database, which will store learner qualifications in one place. The NAQIMS will draw on this information and educational data held by other national repositories.

The NAQIMS was developed with the intention of solving some obstacles that were affecting productivity in the area of accessing learner data. Given that different institutions held learner data but did not communicate with each other, obtaining learner information was an arduous task, with wait periods for data that were not readily available when required resulting in certain

processes coming to a standstill while the data were being collected from somewhere else. Dealing with data from a large system such as education is complicated by the number of users who need access to data. Some of the challenges include the lack of a central database on Qualification Awarding Institutions (QAIs) and qualifications, as well as difficulty in ascertaining student dropout, progression and completion rates. The challenges for higher education institutions (HEIs) and TVETs include the lack of a nationally accepted credit accumulation and transfer system, as well as the rampant production of fraudulent certificates.. Students also face challenges of their own, such as a cumbersome recognition of the qualification process for local and international students, and data that do not provide trends on qualifications to inform decision-making on further education. Last but not least, challenges for the public itself (still an important stakeholder) include labour-market access, the disconnect between qualifications and actual skills in the workplace, and employers' lack of a single reference point to verify candidates' academic credentials. All of these challenges needed to be addressed in an innovative, sustainable and future-oriented manner.

The NAQIMS is essentially a system for registering QAIs and qualifications, and managing learner records. It leverages blockchain technology, a distributed digital ledger used for any exchange of transaction information, agreements/contracts and tracking. There, all transactions are recorded on a block and across multiple copies of the ledger which are distributed over many nodes (stakeholders). This system is highly regarded for its transparency and high level of security. This solves many issues related to trust in the information provided, especially when dealing with fraud in the awarding of qualifications (as previously mentioned).

The benefits envisioned with the system cover the different stakeholders who both feed information into the system and need to retrieve other information from the system that would traditionally be held by other stakeholders. Following are some of the other benefits of the NAQIMS, depending on the stakeholder:

KNQA

- access to education sector analytics and reports
- quick and efficient processing of requests
- use of data to verify certificates

TVET institutions

- verifiable system for credit transfer and accumulation
- use of centrally sourced data for admission
- access to analytics and reports on course data

Students

- access to their academic profile and history
- digital depository of their certificates
- trends on employability

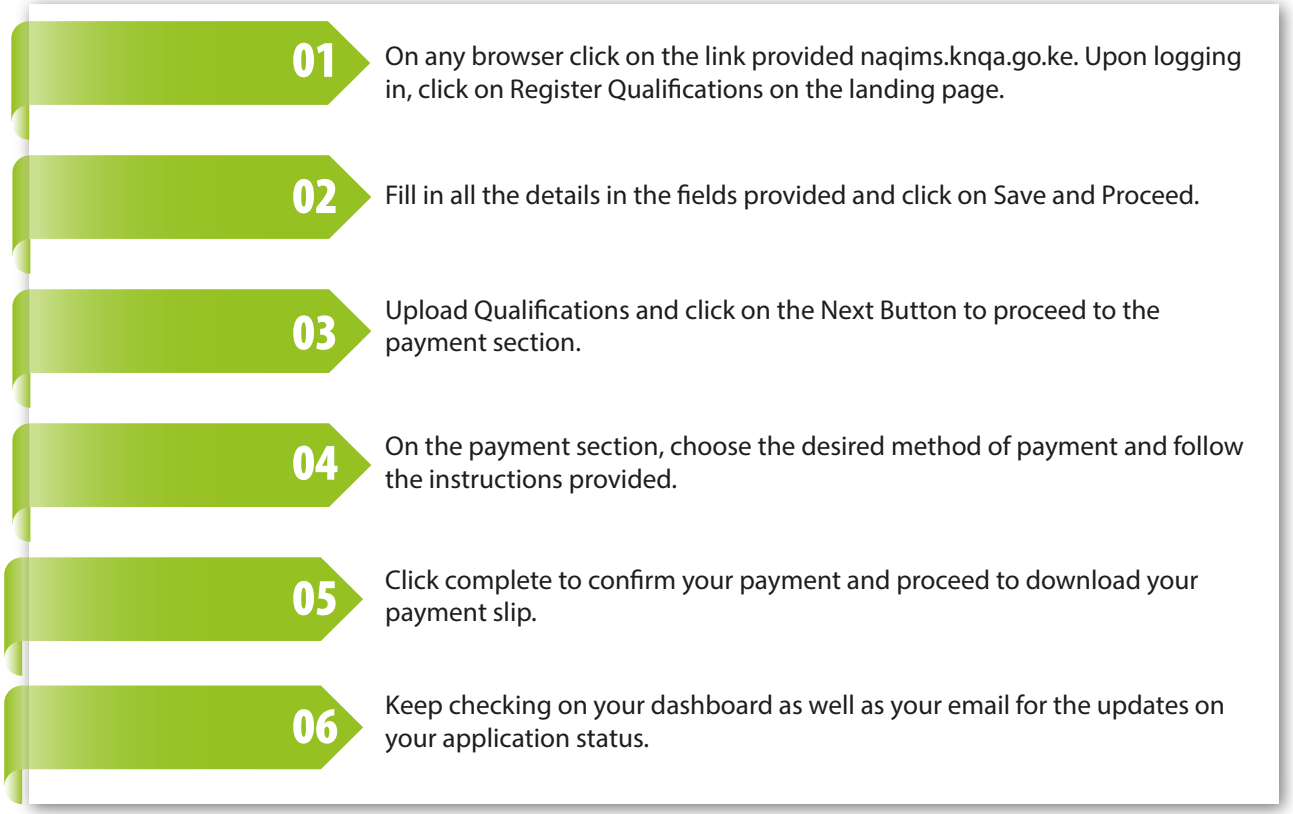
Employers

- real-time verification of certificates produced by candidates

The overall benefit of the NAQIMS is that it will facilitate the management of education in Kenya. The system's use of blockchain technology is intended to create trust in the system through the transparency offers and the security that comes with it for all involved. By removing intermediaries from the system, the NAQIMS system will result in time and cost savings. It is also a move towards making Kenya more accessible to the international community.

In practical terms, all users must register on the NAQIMS before they can use it, after which they can access the different links on the landing page to register their qualifications. This is one example of the different registrations allowed through the system. Registering qualifications is a five-step process that involves filling out a form to capture the requisite details, then uploading the qualification before proceeding to payment. Once this done, users can track their application status on the system's dashboard under their profile or check for email communication.

Figure 3. Steps involved in registering a qualification on the NAQIMS



Source: Authors.

The system presents some potential challenges, such as data volume, data validation and verification, and data integrity, for which some solutions have been proposed. First, ensuring that the datasets submitted by the QAIs have sufficient payload capacity may be a solution for the high volume of data that may be captured in the system. Second, ensuring that both the system design and QAIs put in place systems to validate and verify data may solve the second challenge. Last, ensuring data integrity means verifying that KNLRD data only originate from the QAIs.

The following lessons learned throughout this process may help other countries/organizations embarked on the same journey to make informed decisions:

- create widespread awareness to minimize fears about data privacy and enhance stakeholder goodwill
- ensure continuous capacity-building of key users of the new system
- map out and involve all stakeholders, beginning at initiation/conceptualization, to minimize resistance
- install and maintain a stable and sustainable finance base

3.4.3 Key takeaways: Kenya

Technical and technological

The authority has embarked on the journey to implementing digital transformation. As many other countries have experienced, the COVID-19 pandemic accelerated some existing digitalization processes. Low-hanging fruit included migrating administrative processes and activities online, such as holding meetings via applications such as Zoom, later moving to hybrid models for delivering education.

The ICT Authority provides direction on the policies and frameworks that guide the implementation of digital transformation in TVET. Digital transformation in TVET was coordinated by the National School of TVET, which launched the first audio school in Kenya to improve infrastructure access by providing sites where trainers could train students remotely. This was followed by regional centres hosted by the National Polytechnics, which initiated the use of LMSs. There were challenges during implementation, related to aligning the trainers and convincing them they could work with the new systems.

Curriculum and qualifications

A growing range of digital skills required for the labour market have been added to the curriculum, thanks to efforts supported by the Kenyan government and international partners. However, online assessments have proved challenging; some have argued this is due to the skill orientation of CBET. When different programmes seek registration, the KNQA encourages them to feature an element of digital skills.

Teaching and learning

The lockdowns implemented during the pandemic forced students to train from home. Modalities of delivering content had to adapt, forcing TVET trainers to work in a different way. TVET teachers who are used to face-to-face interactions with students have been reluctant to embrace the new way of teaching. Additionally, as a KNQA representative noted, 'preparedness of trainers, in terms of pedagogy and digital readiness' has contributed to their reluctance to adapt to the new conditions. Centres were therefore established to train trainers.

Sustainability and resilience

Insights from the KNQA emphasized ensuring that digital transformation in TVET is aligned with the government mandate to realize the SDGs. As the KNQA notes:

- Through digital transformation, which for instance led to the introduction of the e-learning model, the Kenyan education and training sector has been able to enhance access and fairness to quality education. Additionally, Kenyan students can access information, services and learning materials regardless of their location, internet connectivity permitting. This is therefore a journey toward realizing SDG 4.
- The Government of Kenya introduced e-government (including e-citizen and e-procurement platforms), which has resulted in higher-quality services and improved access for all citizens. This has also resulted in higher ease of doing business in education, increased efficiency, enhanced service delivery and of course, should also lead to improved productivity.

3.5. Tunisia

3.5.1 Country context: Tunisia

A member of the Middle East and North Africa (MENA) region, Tunisia has had relatively strong economic growth over the past two decades, thanks to an expanded service sector and a more diversified economy. In the late 1980s, Tunisia made schooling compulsory until age 16 and introduced a vocational training curriculum. Secondary enrolment doubled, and tertiary enrolment grew at an even faster rate. Public VET growth was more modest, stabilizing at between 70,000 and 80,000 learners a year. The 2008 global economic downturn – and the 2010–2012 revolution in Tunisia – weakened the government's capacity to advance policy direction and implementation.

The Tunisian government is working to strengthen the labour market's capacity to absorb high proportions of unemployed youth into sustainable employment in order to ensure inclusive economic growth. It aims to create more robust links between education and skill development, and industry demand for skills. Currently, VET systems worldwide have the opportunity to exploit digital transformation advancements in ways that equip graduates with occupational skills relevant to emerging labour-market needs. The question is the following: how well-placed are LMIC VET systems like Tunisia's to respond to the challenges? This chapter identifies and explores features of the national VET system, and lecturer/teacher participation, with regard to the current and future influence of digital transformation in TVET.

Table 11. Key statistics of TVET in Tunisia

KEY STATISTICS

Vocational education

Enrolment in secondary vocational, both sexes (number)

95 thousand

of which female (%)

36.7%

General education

Net Enrolment Rate, secondary education, male (%)

—

for female students

26.2%

Education finance

Government expenditure on education (% total)

22.7%

on vocational education (% of total)

not available

TVET INSTITUTIONS AND RESPONSIBLE MINISTRY

VET Centres

136 (2020)

The Tunisian Agency for Vocational Training (ATFP)

The National Centre for Instructor Training and Training Methodology (CENAFFIF)

1 (2020)

The Ministry of Employment and Vocational Training

Vocational Training Centres

39 (2018)

Agricultural Extension and Training Agency (AVFA)

Source: UNESCO-UNEVOC Country Profile (UNEVOC, 2022e).

3.5.2 Case study: Tunisia

Public TVET provision in Tunisia is the responsibility of three agencies that reside within the Ministry of Vocational Training and Employment (Ministère de la Formation Professionnelle et de l'Emploi).

The largest share of VET training is generated through the public Agency for Vocational Training (Agence Tunisienne de la Formation Professionnelle [ATFP]), which provides accredited vocational training for 80 per cent of the students enrolled in initial vocational training. The public institutional trajectory of VET training is as follows: upon completing nine years of basic education, learners are eligible to undertake two years of vocational training to obtain an initial certificate of competence. After a further two years of training in an occupational field at a specialized centre, a certificate of professional aptitude is awarded. In consultation with employers with high recruitment needs, the ATFP also provides higher education or other graduates with specialization training and skills. Programmes cover a spectrum of more than 10 economic sectors in about 140 centres.

Only 15 per cent of all VET learners attend centre-based training, and 11 per cent of all VET learners complete accredited programmes (ILO, 2019). The bulk of TVET is delivered through workplace-based learning (alternation) and employer apprenticeships (ILO, 2017a). This component is driven by the National Centre for Lifelong Learning and Professional Development (Centre National de Formation Continue et de Promotion Professionnelle [CNFCPP]), which offers continuous vocational training opportunities directly to individuals or through employers. Tunisia has a strong tradition of informal apprenticeships, and lifelong learning and continuous vocational training through CNFCPP mostly take the form of non-formal learning.

The National Centre for Instructor Training and Training Methodology (CENAFFIF) supports the first two

agencies by developing and modernizing curricula and creating didactic tools, including applications and other artefacts for proper application. It also trains TVET teachers and instructors, with a broad mandate to cover all instructor training and CPD.

The National Agency for Employment and Self-Employment (Agence Nationale pour l'Emploi et le Travail Indépendant [ANETI]) offers active labour-market programmes and labour-market intermediation to help unemployed workers, especially from vulnerable groups find jobs. ANETI's work is highly relevant, as it can channel workers towards further training at the above-mentioned institutions.

To broaden the picture of VET structures, the section below provides some examples of initiatives undertaken by various public and private stakeholders to advance Tunisia's digital transformation:

- Early establishment of a flagship Tunisian virtual school, according to Decree No. 119 of 2002, as a distance learning and training platform offering basic-to-secondary education courses and activities, as well as training for teachers.
- Partnerships with international companies, such as IBM and OpenClassroom, to offer an online training platform for Tunisian job seekers.
- An innovative conceptual approach to incorporate generic lessons into a training programme, following the competency-based approach launched by CENAFFIF.
- Novel blended vocational training created by CNFCPP through the 'Open School for Workers' (École Ouverte des Travailleurs), providing around 10,000 workers with the opportunity to register annually to obtain a certificate after completing a blended online learning course.
- Policy establishing a performance-measurement system of indicators from the National Observatory of Employment and Qualifications (Observatoire National de l'Emploi et des Qualifications) for the national vocational training framework.
- Advancing the green agenda by establishing training centres delivering courses that enable unemployed graduates to become photovoltaic system installers, a collaboration between the Tunisian government and Germany's GIZ.

This case study focuses on the systemic level, considering digital transformation in TVET in Tunisia's public ATFP programmes through the prism of challenges in skilling and upgrading VET trainers and educators. It is important to acknowledge that numerous TVET institutions with different mandates offer training in the public or private sectors, with programmes providing apprenticeships or dual modes of delivery that may be accredited or non-accredited. This can create variations in demand for VET lecturer/instructor skills or experience, which the public and private sectors are pressured to supply. The demographic make-up of youth populations in Tunisia poses further questions when it comes to designing programmes that include digital transformation in TVET answering a wide range of issues, such as:

- low- and medium-skilled youth in rural areas working in informal jobs or as unpaid contributors to household production
- low- and medium-skilled young apprentices/workers employed in rural and urban small enterprises, or working as self-employed entrepreneurs
- low- and medium-skilled youth with school certificates seeking better-quality jobs, primarily in the urban formal sector
- medium- and high-skilled youth in urban areas seeking career or salary advancement
- high-skilled, technologically proficient youth in urban areas interested in becoming self-employed

The varied needs of different demographic groups require VET instructors and lecturers to adapt programmes' curricula, pedagogical approaches and delivery modes. The social and economic conditions of LMIC countries like Tunisia, with multiple forms of inequality – also in terms of exposure to digital transformation in TVET before and during COVID-19 – also present trade-off decisions in terms of TVET design and delivery. In this vein, it should be noted that the digitalization of Tunisia's sizeable informal economy, and government policy, may impact skill demand in both the formal and informal economy, with implications for VET skills training.

A few important factors can mitigate progress towards implementing the digitalization of VET systems such as Tunisia's. One prominent social challenge currently facing the country is high unemployment, especially among its youth. As indicated above, ANETI offers active labour-market programmes and intermediation to support unemployed workers, but this has financial implications for VET training programmes. The Ministry of Vocational Training and Employment, which directs ANETI, is required to allocate its budget between VET on the one hand and active labour-market programmes on the other – which, given the problem's demographic scale, requires a large investment of public funds, mostly of which cover operating expenses. This, in turn, hampers funding for VET, including the training of VET lecturers/instructors. This trade-off affects the ability of VET to introduce digital transformation in TVET, which offers long-term savings, but whose initiation costs, including lecturer/instructor training, require increased financial outlays, which are constrained in Tunisia (ILO, 2020, p. 10).

A second concern for Tunisia is that the centralized management of VET training hinders the deployment of lecturers to fill vacant posts. An institution manager observed that regional dispensation to adjust numbers impedes the effective redeployment of teachers among training centres, and the limited flexibility of budget procedures prevents equitable allocation of resources. The manager also reported that training centre budgets are rarely linked to student numbers, leading to an unequal allocation of resources, with over- or understaffing in many centres.

A third concern is that moderate progress has been made in institutionalizing digital transformation in TVET in lecturer practices at VET centres. The experience of the reforms suggests that take-up by teachers/lecturers can be slow. In the recent past, when a competency-based approach to learning was promoted, it took a long time to embed in the teaching and learning processes of VET institutions. Nevertheless, participants in this study indicated that teachers or instructors in schools or VET institutions have increased their use of ICT in their lessons, a development that is facilitated by the delivery of fixed or mobile projection units (desktop PCs or laptops + video projectors) in all education and training establishments. However, not all centres could access online data services on demand to take full advantage of the audio-visual hardware. On a positive note, greater proportions of VET instructors – i.e. 53 per cent of teachers and 62 per cent of trainers – reported using blended learning activities at least once in 2022.

Although the legislation holds that trainers and learning advisors must be evaluated regularly, this is not implemented systematically. The ability of public education authorities to understand and report on digital transformation in TVET use among VET teachers strategically depends on whether VET lecturers undergo skill assessments, rather than self-reporting in ad hoc surveys. Public institutions in Tunisia, particularly those within the ATFP, are encouraged to use the National Vocational Training Quality Standard (Référentiel national qualité de la formation professionnelle) to determine their self-positioning, which may be used to generate an improvement plan. However, use of this standard is at the discretion of the individual training centres, which may choose to implement it or not, and are not required to share their positioning either internally with their teams or externally. In this respect, Tunisia has the opportunity to lead efforts to understand how digital transformation in TVET is assimilated and used by VET lecturers.

3.5.3 Key takeaways: Tunisia

Technical and technological

Tunisia faces several challenges at the technical level. One issue is the need to improve and further invest in the digital infrastructure to drive the international integration of the economy, and to enhance digital access in remote inland regions. There are also challenges at the industry level, where technological change is very rapid. For example, Tunisian automotive cluster firms need to adapt to the increasing digitalization of production processes, which change job tasks and sectoral skill requirements. This poses a serious challenge to the institutional ability of TVETs to rapidly create appropriate training that will make the Tunisian industry competitive.

Curriculum and qualifications

Senior management at the Ministry of Vocational Employment and Training (Ministère de la Formation professionnelle et de l'Emploi) indicated that developing the curriculum, and renewing knowledge and skills in a range of subject and occupational areas

in order to adapt to the new digital transformation changes, is complex and time-consuming. Adaptations for teaching and learning that use digital technologies are just one aspect of an interconnected set of TVET curricular systems. It is crucial to incorporate digital transformation in TVET-related skills in general curricula, as well as occupation-specific curricula that match with the current and future paths of economic sectoral development linked to specific sets of industrial activity and occupations.

Teaching and learning

The cohort of lecturers or instructors currently working in the Tunisian VET system is ageing, and the government has not hired many lecturers over the past decade. As teachers mature, their willingness and ability to adapt to new approaches may lessen. During the COVID-19 pandemic, VET teachers expressed degrees of resistance to teaching new and unfamiliar programmes using novel techniques. Given the reportedly low salaries in the teaching sector, trainers commonly hold two jobs, which diverts their interest from teaching and negatively impacts the quality of their teaching. In the process of transforming the VET sector, substantial strategic consultation, planning and development work will need to be done with VET lecturers, including the possibility of opening the profession to future hiring.

Sustainability and resilience

Tunisia faces high levels of youth unemployment, exacerbated by inequalities in access to work between young women and men, and between youth who live in cities and those who live in rural areas and small towns. These features create pressure to create an inclusive labour market and make economic well-being more accessible to households. The TVET sector is relatively small compared to higher education enrolment, which is larger and contributes to graduate unemployment. Ways of enhancing the role of TVET in generating sustainable employment through reliance on digital transformation in TVET include deploying entrepreneurship programmes that exploit digital transformation in TVET in providing services/products, or identifying applications of digital transformation in TVET to specific Tunisian sectoral value chains that enhance synergies between technology, skills, growth and employability (Arthur, 2022).

04

Practices and trends in digital transformation in TVET

The purpose of this chapter is to unpack the literature and case-study findings, and present commonalities, trends and recommendations that may be helpful to decision-makers facing many competing demands as digital transformation becomes mainstream in TVET. This section is framed according to the conceptual framework, with each subsection presenting the cross-cutting findings and trends from the literature and case studies, and offering key recommendations for policy-makers to consider when engaging in the digital transformation of TVETs.

4.1 Digital transformation in TVET for technical and technological development

The technical and technological level deals with systems, data and efficiencies, and includes both infrastructure and administrative aspects. The administrative level includes policies, frameworks and government agencies at the national level, and issues related to TVET management at the institutional level. It speaks to the alignment and use of data across sectors, particularly data from education and industry. The infrastructure level includes access to technology, particularly the infrastructure and connectivity needed to digitalize routine processes such as registration, assessment and certification.

Infrastructure

At the national level, countries reported increased investment in technology. Examples in the case studies included installing an optical fibre cable linking Tunisia with Europe, India's 'Digital India' digitization drive and literature contributing some well-documented cases, such as the 'Digital Bangladesh' initiative. The Indian case study demonstrated how an LMIC can tackle digital transformation in TVET head-on, as the GoI has sought to ensure that all Indians have access to the internet and affordable data packages. India now has boasts 61 per cent internet availability, over 834 million internet subscribers and one of the lowest data costs in the world, at USD 0.68 per gigabyte (Awasthi, 2022). This national process has shifted the entire economy to digital internet banking and payment platforms in response to currency shortages. With increased connectivity, underserved and remote village areas in India now have access to real-time information and opportunities.

Other case-study countries are focused on establishing infrastructure at TVETs at the same time as they expand remote access. As noted in Section 3.1, the most marginalized populations are the least likely to have access to infrastructure. Under such circumstances, and without additional intervention from government, remote access efforts will likely widen the 'digital divide' and create further economic disparities within the population.

Beyond the issue of individual access, most countries expressed concerns about insufficient digital access within TVET institutions, both in terms of the availability of necessary equipment and the state of this equipment, although reports noted measures taken by both government and trusts (such as HEART in Jamaica) to remedy the situation. In Kenya, while the broader framework for digital transformation was in place, the government was moving too slowly in addressing the high cost of the internet and connectivity issues for far-flung areas. The fact that TVET institutions in many countries, including Kenya, are based in rural areas and draw learners from poor backgrounds makes it harder for these students to access both learning and the infrastructure and equipment that allow TVETs to train students in relevant skills for the labour market. Industry innovations such as Starlink were positioned as viable solutions to access and affordability challenges, but whether the price point of innovations will expand market access enough to reach the most marginalized remains to be seen. It is likely that subsidies or other government initiatives, as well as wise investments, will be necessary. The case-study countries' emphasis on connecting rural areas and making investments in e-commerce have encouraged rural development agendas in China.

Every case study identified systemic – and mostly inhibiting – factors within education and training systems that impact digital transformation in TVET. Positioning TVET as a pathway following ordinary school education was a key consideration. In Tunisia, for example, challenges in introducing digital transformation to post-school VET programmes are 'inherited' from the schooling system (see Section 3.5); the lack of technical infrastructure in basic education prevented learners from becoming familiar with the online environment and acquiring the skills required to use technological tools.

Administrative

In addition to hardware, software and internet access, one of the necessary foundations for beginning a digital transformation is the digitization of data and the establishment of national, interlinked data systems. One such system is national identification, which is now being used in countries to access government services and in some cases, educational records on government platforms. Kenya, for example, has developed a portal which every citizen of the country can access using a unique number assigned from birth to death, managed and coordinated by the Integrated Population Registration System. The portal centralizes all citizen data to avoid duplication of data stored by different institutions. An Executive Order of 2018 established the National Integrated Identity Management System as part of this initiative; one of the respondents in the KNQA stated that qualification data (including for TVET) are also held in this database. Upon registration, citizens receive a 'Huduma Card', which is essentially a digital multipurpose identity card with information stored on an electronic chip that can be used for many purposes, including as a travel document in within the EAC.

Digital transformation in TVET presents a variety of challenges, notably in terms of integrating technology and data with existing systems and databases. This can be a difficult task, which requires ensuring that the new technology is compatible with existing systems, and that data can be seamlessly transferred among them. To tackle these challenges, organizations can adopt an aggressive partnership approach with employers and industry, working closely with industry leaders to understand their needs and tailor digital transformation efforts to them. The case studies showed a clear trend across the five countries for using the potential of digital transformation in TVET to link supply-and-demand systems in more innovative ways, thereby possibly increasing chances of finding formal employment.

Case studies in Kenya and India demonstrated the great value of maturing national qualifications data repositories. Kenya's intention is to develop a central portal for all citizen data to avoid the duplication of data (and effort) captured by different institutions. In tandem with other government institutions, policy direction by the KNQA and the establishment of the ICT Authority and other regulators were important elements in moving the implementation forward. Within the KNQA, the department of registration and accreditation guides the collection of data for the portal. In addition to such innovations in information management and sharing, including the provision of services (especially in education), the KNQA still manages other service portals. It is currently developing a large project to connect the regulators with which it works, along with providers of basic education, higher education, TVET and industrial education, to harmonize their activities.

In India, the digital transformation in TVET journey started with the task of getting systems aligned, since the country had so many schemes and projects running under the aegis of Digital Skills India. As a result, data and management platforms were created to ensure convergence and interoperability across projects and training providers

4.2 Digital transformation in TVET for curriculum and qualifications

This second level of the digital transformation in TVET conceptual framework deals with the transformation of curriculum and qualifications, or the introduction of new knowledge in the curriculum. This could include new courses or skills (for example, in cybersecurity, programming and cloud computing), or integrating digital skills into other courses (for example, including the creation of PowerPoint presentations or use of spreadsheets as learning outcomes for general courses). At this level, digital transformation would be achieved if, for example, enrolment and student survey data were synthesized with industry and partner data to determine new skill needs and necessary curriculum revisions. The inclusion of practical components, including work-integrated learning, is a key feature of TVET programmes. While some of these components could be offered through simulated modes, there is no doubt that in-person workplace exposure remains critical, as the country case studies all demonstrated.

While hybrid formats were associated with cost savings and improved access, they also highlighted the importance of programmes requiring practical exposure. Several innovations in the delivery of TVET programmes were reported. Collaboration between the Tunisian government and GIZ involved wide-ranging interventions, such as creating a unique platform to support VET trainers (including in building MOOCs) and adapting digital knowledge and pedagogy to meet training quality requirements, resulting in higher levels of student engagement and performance. There were

similar examples in Kenya, India, Brazil and Jamaica, although very few (if any) of these programmes have been evaluated for their impact.

TVET systems internationally have been influenced by CBET approaches to curriculum design and assessment (Boeher, 2017; Idrissi et al., 2016). In the case studies, several of the institutions made a direct link between different forms of CBET and digital transformation in TVET. Examples show that CBET is 'skill-oriented', and therefore 'online assessment has been a challenge… the trainers are used to face-to-face'. CBET underpins Brazil's model of digital transformation in TVET and the work of SENAI. Similarly, in Kenya, the KNQA actively encourages a transition to CBET.

4.3 Digital transformation in TVET for teaching and learning using technology

The third level involves transforming teaching and learning to promote greater agility in engaging students. At this level, digitization involves creating digital learning records (e.g. transitioning from paper grades, assessment records or evidence portfolios to their digital equivalents). Organizing data likely involves an LMS. The streamlining of processes could include:

- new methods of instructional delivery, such as blended or remote learning
- new tools for learning and assessment, e.g. digital or remote assessments, automated grading, and multimedia resources or simulations
- new methods of pedagogy, such as incorporating design thinking, project-based learning, 'flipped classrooms' emphasizing independent learning prior to lecturer engagements and the 'use-modify-create' digital learning framework.

Ageing cohort of TVET instructors

The ageing cohort of TVET instructors should certainly be noted, especially in Tunisia. For a long period, the government has been hiring few VET workers, raising concerns that some trainers who are about to reach the age of retirement will not be replaced. This implies an ageing lecturer cohort, who have been in relatively long service. As teachers mature, adapting to new approaches and new knowledge becomes more difficult. One participant alluded to some degree resistance from VET teachers' to teaching new and unfamiliar programmes using novel techniques. In addition, given the low salaries in the teaching sector, it is common for trainers to hold down two jobs, which leads to vested financial interests and can be detrimental to the quality of teaching. In transforming the VET sector, substantial strategic consultation, planning and development work will need to be done with VET lecturers, along with entertaining the possibility of opening the profession to future hiring.

In Brazil, SENAI adopted a proactive approach to increasing its workforce to deal with both increased demand and enrolments, and also replace several trainers/lecturers/trainers who were ready to retire. To mitigate the loss of institutional memory and expertise while simultaneously building up its capacity, SENAI made a strategic move to increase its use of technology, rather than increase its infrastructure.

TVET instructors require upskilling

One of the challenges often facing LMICs when pursuing digital transformation is lecturer capacity. Additional structural support can help teachers and lecturers transform their practice in stages. The Brazilian case study describes several types of structural support provided as part of the 'SENAI Programme of Educational Standardization', which supported a shift from face-to-face instruction to a blended learning model (80 per cent remote, 20 per cent in-person) in TVETs. The support included centralized development of curricula and courses, teaching plans, textbooks, online lessons, teaching kits and reference simulators. Only after the courses and materials were in place were teachers, lecturers, trainers and tutors offered intensive programmes on the content and how to deliver the course. This means that training could move from abstract concepts (e.g. theoretical descriptions of how to develop online courses) to concrete applications (e.g. teaching someone how to deliver a specific set of content using a specific platform, textbook and resources). This method dramatically lowers the 'bar to entry' for TVET lecturers and will enable them to apply insights gained in training more quickly and efficiently.

The Indian case study shows that teachers and lecturers need to be equipped with digital skills and knowledge to teach digital content effectively. This can be achieved through professional development opportunities, workshops and courses, as has happened so far. However, adopting a learner-centred approach would

also help teachers and lecturers emphasize student engagement and active learning. This can be achieved through technology-enhanced pedagogy, such as online and blended learning, gamification and VR/AR.

The Kenyan and Brazilian case studies highlight similar issues. Lockdowns enforced at the height of the pandemic, which forced students to stay at home, meant that the modalities of delivering content had to be adapted, forcing TVET trainers to work differently. Despite the special circumstances, there has been reluctance to embrace the new way of teaching, especially on the part of TVET teachers who are used to face-to-face interactions with students. Additionally, the 'preparedness of trainers, in terms of pedagogy and digital readiness' has contributed to this reluctance. In Brazil, respondents indicated that some teachers were initially resistant, fearful, anxious or uncertain about the transition to blended learning. Hence, SENAI conducted intensive training on digital skills and the platform for teachers and tutors, as well as providing them with stable connectivity and computers. Early adopters' successes and expertise helped spread awareness and skills among teachers.

New methods of instructional delivery

Online and hybrid approaches were increasingly used as a substitute for face-to-face training during the COVID-19 pandemic In the meantime, young, post-school learners were coming from a schooling system that relied on traditional classroom teaching. This meant that many TVET centres had limited capacity to deliver courses, let alone offer online courses based on progressive methodologies. Because of this constrained engagement with the new modes of training and pedagogy, many TVET centres were relatively unprepared when courses went online during the pandemic. Countries that had started the digital transformation in TVET journey prior to the pandemic, such as Brazil and India, undoubtedly handled the challenges more successfully by effectively ramping up existing interventions.

Today, these new approaches are increasingly used post-COVID-19, as they offer more flexibility and ease of access. This means that lecturers are likely to reproduce a more interactive teaching approach.

Despite the many challenges that limit the introduction of digital transformation in TVET, respondents across all five case studies unanimously supported digital transformation in TVET to enable more individualized learning, despite the limitations. Given the current technical ability of institutions and candidates, respondents confirmed that digital transformation in TVET has helped students accumulate knowledge at their own pace. Adaptive learning software and digital resources also provide students with the flexibility to learn at their own pace, and in a way that is tailored to their individual needs and abilities.

In India, TVET institutions give students more individualized and interesting learning experiences through digital technology, as well as making education more accessible to students in rural or underserved regions. Digital transformation in TVET institutions is extensively used in the textile and welding sectors. Digital transformation in TVET improves the quality of the curriculum, not only to better meet industry needs but also to become more learner-centric. Digital transformation in TVET can consider students' needs and how learning best happens for them, especially among the younger population, where the impact is already being observed.

New forms of pedagogy

Distance learning is increasingly driven by a platform-based approach. Participants were aware of the 'distance' between teachers and learners owing to technology, and how this can manifest as a lack of immediate access to assistance or problem-solving. Here also, Brazil's SENAI has emphasized proactive management and reaching out to students who perform badly on activities. One key observation was that institutions 'cannot lose their DNA' when going digital. This is a concrete example of a mitigation strategy put in place to adequately maintain a core function of student support.

4.4 Contribution of digital transformation in TVET to sustainability and resilience

The fourth and more advanced level of digital transformation in TVET is sustainability and resilience, which focuses on digitally enabled practices in TVET that contribute to sustainable development and resilient societies. In this case, we have taken our lead from the UNESCO TVET Strategy for 2022–2029, which envisions

TVET as playing an integral role across a number of lines of action and activities (UNESCO, 2022c). Many of these are featured in the cross-cutting findings summarized below.

Foundations for sustainable digital transformation in TVET

As mentioned earlier in this report, introducing emerging technologies into the labour market has resulted in two substantive effects:

- The skill requirements of jobs related to technology have outpaced the growing education levels of the workforce, generating a skill-biased change and ultimately leading to higher wage inequality.
- Routine, repetitive tasks are being replaced with more efficient technology-based systems.

In the case of LMICs, the weight of labour-market demand tends to lean toward labour-intensive employment, while demand for digital skills depends on the services, manufacturing and trade sectors. This places LMICs at the periphery of the expected effects because of technological changes. While the main trend towards growing inequality will be felt just as much in LMICs, the pace will likely be slower, providing an opportunity for putting in place transitional measures. Kenya is a case in point: no effort had been made to integrate mobile technology for voice calls and payments into the TVET system and as a result, payments technologies were promoted by VET programmes, supporting entrepreneurs and small business operators in broadening their access to clients and suppliers. The SENAI case study in Brazil provided an important and salient insight. The SENAI approach emphasizes 'people and culture first', following by using technology to drive innovation, and enhance processes and techniques for delivering education. According to the respondents, this approach was central to the success they achieved through the programme.

Private-sector investment in each country's response to the competitive global challenge of digital transformation in TVET also has substantial implications for future economic growth. Brazil, Jamaica, Kenya and Tunisia incentivize employer contributions to employee training through a skill levy paid by the employer; in India, this function is multimodal, involving among others the NSDC and the National Skill Development Fund (NSDF), which urge private-enterprise investment in skill development. These provisions are important to secure funding and success of digital transformation in TVET programmes in LMICs. The direction and distribution of digital transformation in TVET funding to TVET institutions must be informed by evidence-based planning and consultation with industry. Within the basket of funds allocated to digital transformation in TVET, it is strategically necessary to vote for sufficient funding for pre-service, in-service and continuous professional development of TVET lecturers in all relevant domains.

New forms of credentialing combined with generative AI

The evolution of LMS systems into interoperable data platforms that can provide a common reference point for both the supply-and-demand side of education and training systems is an important trend. MOOCs will likely continue to be developed and used, but there is no doubt that the trend towards micro-credentials is growing at an exponential pace (ILO and UNICEF, 2023). An important feature of this trend is the global recognition that all forms of learning matter, and that this learning can be recorded, aggregated and disaggregated through digital means. While it may be too soon to state that the emerging platform-based credentialing systems will replace the qualifications frameworks of the last three decades, this is not impossible. Simulated learning, also using VR/AR, is growing exponentially, exerting direct pressure on TVET systems to develop more cost-effective modes of assessment. However, this comes with the caveat that in the TVET context at least, there will always be parts of the curriculum that can only be delivered in a physical context at the workplace.

> New forms of credentialing, proxied by micro-credentials, are influencing how learning is recognized, and critically, how formal, non-formal and informal learning can be better articulated with jobs. Likewise, new forms of generative AI, proxied through ChatGPT, Copilot and Google Bard, are disrupting content creation at many levels, also raising critical questions about ethics (UNESCO and Mila, 2023) and intellectual property.

The interface between generative AI and new forms of credentialing is an interesting new area that could be explored further, particularly to examine biases that may impact negatively on future TVET delivery.

Digital transformation in TVET can harness the youth dividend in LMICs

By and large, LMICs have majority youth populations. The United Nations *World Youth Report* projections suggest that the youth cohort in sub-Saharan Africa will 'continue to grow and will likely represent almost 30 per cent of the world's youth by 2050, up from 18 per cent in 2020 and almost 22 per cent in 2030', with Northern Africa and Western Asia also seeing increases (United Nations, 2020, p. 40). The report does, however, state that this trend may reverse in all regions in the longer term. This young age group is naturally more inclined to use technology and as a result, offers a natural opportunity for digital transformation in TVET. Notably, these young student populations are dominated by males. This is a longstanding characteristic of TVET systems, and even more so among LMICs. While youth may be more inclined to use technology, it makes sense to provide more mature students with additional support to help them navigate the platforms and communication channels associated with digital transformation in TVET. The case study from Brazil provides a good example of how these aspects can be balanced.

Lack of legal and policy frameworks for digital transformation in TVET

An important observation across the case studies is the lack of legal and policy framework for digital transformation in TVET. The research team felt this gap should be highlighted and further explored. Most of the digital transformation in TVET developments highlighted in this study can only be sustainable if fair and equitable principles are enacted, including those related to data privacy and international support for non-proprietary open-source technology stacks that can be used by LMICs with the necessary customization, but not the exorbitant costs often associated with such processes.

Resilient societies

The ultimate purpose of a TVET system is to prepare citizens for the current and future world of work. Digital transformation in TVET can facilitate this goal, but also detract countries from excellent long-term interventions that should not be discarded without proper interrogation. Digital transformation in TVET can support TVET systems in building resilient societies in very practical ways. For example, a more seamless supply-and-demand system can effectively identify the skills required for the transition to digital and green economies. Additionally, rights-based education for global and participatory citizenship can be included in curricula in more meaningful and integrated ways than was possible using low-technology teaching and learning modes. Finally, TVET institutions embracing digital transformation can undoubtedly be better promoted as places for social integration, cohesion and green citizenship.

05

Recommendations for pursuing digital transformation in TVET

The set of recommendations below are aimed primarily at policy-makers but also target TVET institutional managers, researchers and practitioners. The recommendations are organized according to the four levels of the conceptual framework, starting with a set of enabling factors for digital transformation in TVET.

5.1 Enabling factors for digital transformation in TVET

A number of enabling factors for digital transformation in TVET in the context of LMICs have emerged from this study. The list is not meant to be comprehensive, as country contexts will always remain a key consideration. In addition, digital transformation in TVET cannot be considered in isolation from other ongoing reforms in TVET. The sections that follow further elaborate on this list.

a. Ensure a level of digital infrastructure that can support digital transformation in TVET at a level and pace appropriate to the country. Although private-sector innovation can be relied on to some extent, enabling policies, along with advocacy, targeted interventions for the most marginalized, and relevant training of citizens are important initiatives in this regard.
b. Place equality and inclusivity at the core of digital transformation in TVET. Ultimately, digital transformation in TVET must contribute to sustainability and resilience in the country. Its strongest contribution lies in creating equal opportunities for larger groups of citizens to gain competencies relevant to this goal.
c. Follow a coordinated approach between institutional transformation and the acquisition of new digital skills by practitioners, managers and policy-makers. Institutional capacity and culture are important enablers to consider in this regard.
d. Develop enabling legislation that leverages digital transformation in TVET to strengthen TVET policies (including regarding data privacy), as well as new skill-recognition systems facilitated by increased data interoperability.

These enabling factors are also considered by the Digital Transformation Collaborative, an initiative by UNESCO and the Global Education Coalition to provide support to national governments in implementing digital transformation in their education systems (UNESCO, 2023c). In the case of TVET, DTC provides support on improving digital infrastructure, coordination among activities such as platform of digital contents and capacity building, as well as new legislation, including law and regulation about secure data privacy, inclusive and sustainable models of expanding access and growth.

5.2 Digital transformation in TVET for technical and technological development

Follow a 'digital transformation in TVET-by-design' approach to infrastructure development

Develop a comprehensive approach to infrastructure development in support of the equitable digitization of TVET institutions and take-up of digital transformation in TVET. At the TVET institution level, accounting for costs and building (facilities and ongoing costs, such as for connectivity services) estimates for three- or five-year planning cycles will likely be very difficult. Some countries have a dedicated agency that focuses solely on engineering and implementing access to quality, high-speed connections at all TVET or higher education institutions. Infrastructure gaps represent a primary constraint on both student and lecturer access. Infrastructure must include physical delivery of electrical power to institutions, access to connectivity, and supply of electrical and digital cabling and hardware in physical buildings. The Brazilian, Kenyan, Jamaican and Tunisian studies all highlighted challenges related to infrastructure development, where global cycles of improved technology development of hardware and software require ongoing expenditure to keep up. The national supply and quality of these infrastructure and services involves different public financing and delivery agencies, requiring coordination and oversight by TVET authorities.

Incentivize employer contributions for digital transformation in TVET

Private-sector investment in each country's response to the competitive global challenge of digital transformation in TVET has substantial implications for future economic growth. One important source of funding for TVETs is employers, through skill levies or other types of mandatory contributions. These provisions help secure the funding and success of digital transformation in TVET programmes in LMICs. Such provisions are in place and centrally managed in four of the five case studies; in India, financing is multimodal

and involves (among others) the NSDC and the NSDF, which promote private-enterprise investment in skill development.

The direction and distribution of digital transformation funding to TVET institutions must include evidence-based planning and consultation with industry. Sufficient funding for pre-service and in-service, and the CPD of TVET lecturers, is necessary in all relevant domains.

5.3 Digital transformation in TVET for curriculum and qualifications

Build interoperable data systems to support digital transformation in TVET

Stakeholders should prioritize data-sharing between public holdings of citizen data, including the sharing of information between different current and future data systems. The links between individual demographic, qualification, work-status and employment data are important, and countries should strongly consider developing National Qualification Authority data systems as an investment in the future quality of VET information systems. Over time, this information will provide a sound basis for AI-informed future planning of VET occupational training at the national and institutional levels. This opportunity is already present in Kenya's KNQA: as data systems and analytical capacity develop in the future, TVET authorities may track systemic and institutional change along different dimensions (e.g. programme administration; teaching methodologies; integration of AI by occupation; and labour-market data, including graduate employment statistics per programme or institution). These data may be made available to the public, subject to ethical provisions.

Expand recognition systems to embrace digital transformation in TVET

National systems that recognize qualifications provide important platforms for individuals who possess skills obtained through experience in digital transformation in TVET for which they do not have a formal qualification. There is great value in introducing credit frameworks and aligning them with a standardized education system of credits. This can ensure that individuals receive consistent and high-quality qualifications with commonly accepted standards and help improve workforce skills and knowledge, making it easier for individuals to transition to more advanced levels and opportunities presented by new careers. Such a platform could support self-employed workers or entrepreneurs with technical skills in the informal economy, accrediting/recognizing their informal skills and allowing them to access decent jobs in the formal economy. This would require cooperation between national agencies charged with accrediting formal qualifications, and agencies involved in adult and non-formal education. In the area of digital transformation in TVET, there exist a number of privately owned skill programmes and qualifications for occupations or roles in digital and allied industries across software, services, infrastructure and devices. This system operates largely independently of public VET systems, but partnerships between public- and private-sector providers could be developed to focus on particular occupations or skills related to DX-TVET.

5.4 Digital transformation in TVET for teaching and learning using technology

Build TVET trainer capacity in digital transformation in TVET

Countries should prioritize the training VET lecturers to teach new occupational skills and forms of knowledge introduced by digital transformation technologies. They should also focus on the CPD of VET lecturers, using constructivist approaches to facilitate teaching and learning and limiting dependency on teacher-dominant styles of teaching.

TVET lecturers need a variety of new skills to engage in the modern world of education and work, including:

- applying digital technologies to teaching activities, e.g. how to use an LMS, create products using general software tools (email, office, etc.) and apply domain-specific tools (simulators, hardware, etc.)
- pedagogical content knowledge (PCK) for specific digital technologies
- developing and teaching of intra and interpersonal skills (adaptability, metacognition, grit, etc.)

The cast studies on Brazil, India, Jamaica and Tunisia discussed the training of trainers and highlighted the central importance of trainer skills in relation to their current roles across their entire career span. Important issues emerging from the interviews included difficulties in appointing trainers to replace ageing cohorts, embargos on trainer employment and the reluctance of trainers to engage with new digital transformation in

TVET demands. The challenges also place high demand on the trainers of trainers, especially in new fields comprising digital transformation in TVET. Interviews and the literature indicate a need to progressively update training on AI in the following dimensions: (a) changes in the meaning and implications of AI as a concept; (b) implications of AI for curriculum change in terms of knowledge, skills and competencies per occupation or trade; (c) implications of AI innovations for teaching/learning strategies; and (d) implications of AI analysis for the future relevance of occupations in the labour market. Delivering updated content requires professional collaboration with industry to keep up with new developments in product or service value chains, leading to new digital transformation in TVET needs. These functions take time and include costs for shifting lecturer time as well as finding substitutes. Training also must be coordinated with the scheduled introduction of technologies, platforms and facilities in TVET institutions.

The modality for training TVET trainers depends on the size of the TVET system in terms of numbers of institutions and numbers of trainers, as well as the areas of specialization and urgency of the need. In some large systems, this might entail creating a pool of master trainers and master assessors with digital expertise. who could in turn train more trainers and assessors as a trickle-down effect to create a bigger pool of individuals. However, this may not be a useful solution in smaller systems characterized by greater sectoral diversity and needs.

Conduct focused research on digital transformation in TVET

Case-study interviews elicited limited discussion from respondents about the results of research on the impact of digital transformation in TVET pilot projects in their institutions, or about research to deepen the effectiveness of current digital transformation in TVET programmes in the areas of curriculum, teaching and students' success in the world of work. For example, government support for research and development on demand and supply of digital transformation in TVET skills can support targeted skilling programmes and curriculum design at the regional and TVET institution levels to identify whether the digital transformation in TVET curriculum as it is taught and internalized by students aligns with employers' skill needs. Equally, the curriculum must address the needs of mid-career workers who require a 'top-up' programme to augment their original skills.

Under the influence of digital transformation in TVET, teaching and learning will change, as will employer demand for skills, in line with the digital transformation of businesses. There is also a need for valid, reliable intelligence in the public and private sectors to consider what works or does not work. A high premium will be placed on good-quality information covering successes and failures in digital transformation in TVET, supported by statistical data, research or analysis to inform evidence-based policy or strategy in the public and private sectors.

5.5 Contribution of digital transformation in TVET to sustainability and resilience

Promote inclusive digital transformation in TVET

The TVET sector encompasses a wide variety of client/student demographics, in terms of the types of sector, occupations and forms of employment in demand. TVET institutions are commonly expected to provide adequate opportunities across these domains. This means that authorities need to create incentives for VET training centres and private-sector employers to increase the proportion of women and other marginalized populations in targeted programmes and occupations.

Countries and institutions are encouraged to adopt a stance that prioritizes the provision of equal access to opportunities and resources to digital transformation in TVET for any currently or potentially excluded groups. This includes the large male and female youth population in the region; women in general; ageing populations; regional, ethnic and migrant populations; refugees; various socioeconomic categories; informal workers; and people with disabilities. Speakers of minority languages are another excluded category. For example, French speakers in Tunisia are unable to access the many English-language materials available online, a challenge that is even greater for speakers of indigenous local languages. Language translation AI alone will not necessarily close the gap.

Recognize that institutional culture matters, including in a digital transformation in TVET context

Based on the literature, the three major pillars that will sustain digital transformation in TVET environments are the digitization of processes, investment in infrastructure and the culture of the institutions themselves (also see UNESCO, 2023b). In this regard,

the DTC Framework (see UNESCO, n.d.) provides a valuable set of indicators across three stages that could be contextualized for TVET settings. Other than the formal rules (such as regulations that govern behaviour), the institutional culture, values and norms of conduct, and interactions of TVET institutions will inform how lecturers (and students) respond to change, including the challenges represented by digital transformation in TVET in relation to:

- their confidence with technology and social media
- their affinity with teacher-centred forms of engaging with students, compared with learner-centred forms of engagement
- their willingness and capacity to change how they teach the curriculum with which they are familiar
- their openness to peer or student assessment
- their sense of accountability for what employers think about their students' competence or suitability

These are vital questions facing digital transformation in TVET and TVET training cultures, which TVET managers must attempt to solve.

5.6 Considerations for further studies and policy alignment

The number of case studies undertaken in this research was limited to one per country. This meant that the cases studies provided a restricted view of existing practices and approaches to implementing digital transformation in TVET in the LMICs at the different levels identified: technical and technological, knowledge and curriculum, pedagogy and innovative practices. However, the relatively high difficulty in identifying innovative projects in each country may also reflect the fact that digital transformation in TVET is still nascent, since the conditions conducive to digital transformation in TVET are just bearing fruit. Furthermore, in the early stage, the research team was aware that networks of digital transformation in TVET practitioners/innovators may be relatively undeveloped, contributing to limited referrals. This suggests a need for TVET authorities to support networks of digital transformation in TVET innovators.

Focus-group interviews were a sound methodological choice to generate multiple perspectives on the selected digital transformation in TVET innovation, based on the recognition that innovations in a TVET institutional environment involve several partners or practitioners. The case studies were more suited to eliciting holistic accounts of the innovations, rather than their distinct pedagogical or learning features. Further research explicitly focusing on practitioner experiences would likely provide intelligence, including lessons learned, on how TVET practitioners introduce digital transformation in TVET concepts into learning and teaching.

Ultimately, the aim of TVET institutions is to improve the opportunities for graduates to find fair employment in the labour market. Therefore, the positive impact of digital transformation in TVET on learning outcomes and successful entry into the world of work is a critical measure of success. Obtaining reliable intelligence on labour-market outcomes, which are vital in fast-changing digital transformation in TVET technological and skill markets, is a crucial gap for digital transformation in TVET pilot interventions to fill.

The apprenticeship system of training combines theory, practical work and workplace experience and practice in students' chosen trade, leading to a trade test that results in an artisan's certificate of competence. In the apprenticeship model, as with the work-integrated learning approach, there was limited consideration of how digital transformation in TVET could be used constructively to enrich training outside of the workplace (as happened under COVID-19).

The literature suggests a strong tendency for new types of programmes to be shorter, providing 'top-ups', catch-up, or 'augmentation' to existing and serviceable skills. This will be especially important given the types of disruptions expected from the introduction of technology, as lower-skilled workers who lack additional training are most likely to lose their jobs as a result of automation. These types of programmes will likely be based on new knowledge that the TVET college staff may not possess. New forms of hiring expertise from industry may be taken up, but the new types of programme configurations were not discussed. The interviews hardly touched on the likelihood of private-sector companies designing and developing entire programmes and curricula which TVET institutions could then offer using their own staff, but without incurring any of the development costs. These would enable quicker responses to new digital transformations in TVET, answering concerns about how to staff and cover all the needs of national TVET institutions internally.

Across all conversations, a major shortfall in the case-study countries, except for Jamaica and possibly areas of Brazil, is the lack of availability of labour-market data broken down by occupation. Hence, TVET institutions should consider implementing tracer studies based on their own

students to quantify supply and demand of graduates. The previous most common form of governance in TVET institutions, which has traditionally been top-down and based on standardized programmes offered from a supply-side point of view, is threatened by demand for a different model because of digital transformation in TVET. This model must involve a non-hierarchical, collaborative effort with industry partners, characterized by greater cooperation with regard to building programmes. This emerging mode implies a higher diversity of course and programme models.

The interface between generative AI and new forms of credentialing is an interesting new area that could be explored further, especially to examine biases that may impact negatively on future TVET delivery. The TVET sector is well-positioned between training and the world of work. As such, the current global interest in each of these areas separately, but also in terms of the interrelationships between the two, provides the TVET sector with an opportunity to not only participate in, but also lead many of the new developments.

While the COVID-19 pandemic has accelerated the digitalization of the economy, it has also made it more urgent to address gender inequalities in the digital economy. The GSMA (2022) reports that while the substantial gender gap in mobile internet use in LMICs had been narrowing in recent years, this progress has now stalled across LMICs, with the mobile internet gender gap even increased in some countries. Women are now 16 per cent less likely than men to use mobile internet across LMICs; in 2020, the gender gap stood at 15 per cent after dropping every year from a high of 25 per cent in 2017. Similarly, the gender gap in smartphone ownership had been narrowing across LMICs, from 20 per cent in 2017 to 16 per cent in 2020, but has reversed over the last year, with women now 18 per cent less likely to own a smartphone. Individuals who still do not own a mobile phone are difficult to reach. They are predominantly women, but also disproportionately rural, less educated and lower-income individuals, who have arguably the most to gain from being connected. Unfortunately, this study was not able to consider the digital gender divide beyond the perspective of access, and the authors recommend a more detailed review of this subject.

The cost-benefit of different interventions at different levels of digital transformation in TVET also warrants a much deeper analysis. There exists scope for a meta-analysis of available data related to the anticipated costs of digital transformation in TVET, whether at the level of the enabling infrastructure or the cost savings stemming from expected efficiencies.

A closer alignment between digital transformation in TVET and the DTC Framework process (UNESCO, n.d.) will be mutually beneficial. While the DTC is broader in its scope, there is very strong alignment with the digital transformation in TVET framework presented in this study. Such alignment will be useful to position TVET as an active contributor in matters of digital transformation globally. On a policy level, this study points to the need for increased synergy and alignment across global frameworks and initiatives. The DTC Framework is a case in point (UNESCO, n.d.). Aligning the indicators and reporting mechanisms of the digital transformation in TVET framework developed for this study with the DTC Framework will position TVET very well, not only as a participant in digital transformation, but also as an active contributor. The same principle applies to the work of the Global Skills Academy and several pan-African initiatives, such as the ACQF.

On a final note, one challenge for this document is that digital transformation in TVET is a process rather than a discrete event. As a result, the advice presented herein on ways to proceed will likely change. This means that much of what is put forward may be provisional, as what is known about digital transformation in TVET at present will likely change relatively quickly. Regular reviews of this space are therefore encouraged.

5.7 Conclusion

This exploratory study on digital transformation in TVET in LMICs was conducted over a relatively short period and with a limited set of case studies. Even so, the research has demonstrated that TVET systems are well-placed to use digital transformation in TVET to enhance their scope, scale, efficiency and effectiveness at several levels: technical and technological, curriculum and qualifications, and teaching and learning. Ultimately, the digital transformation of TVET systems can contribute to an equitable and resilient digitalization of LMIC societies, ensuring inclusion and the provision of necessary digital and non-digital skills.

We trust that this report will motivate countries, regions and international development agencies to embrace digital transformation in TVET with the necessary care, but also the recognition that digital transformation will become increasingly central to TVET reform.

References

Admiraal, W., Huisman, B., and Pilli, O. 2015. Assessment in massive open online courses. *Journal of E-Learning*, Vol. 13(4), pp. 207–216. https://files.eric.ed.gov/fulltext/EJ1062116.pdf

Al-Huneidi, A. and Schreurs, J. 2012. Constructivism based blended learning in higher education. *International Journal of Emerging Technologies in Learning (iJET)*, Vol. 7(1), pp. 4–9. http://dx.doi.org/10.3991/ijet.v7i1.1792

Ahmed, M. 2022. *The modifications in the digitization of education*. The Hans India. https://www.thehansindia.com/hans/young-hans/the-modifications-in-the-digitization-of-education-734268

Ahn, S., and Nyström, S. 2020. Simulation-based training in VET through the lens of a sociomaterial perspective. *Nordic Journal of Vocational Education and Training*, Vol. 10(1), pp. 1–17. https://doi.org/10.3384/njvet.2242-458X.201011

Amis, J.M., and Janz, B.D. 2020. Leading Change in Response to Covid-19. *The Journal of Applied Behavioral Science,* Vol. 56(3), pp. 272–278. https://doi.org/10.1177/0021886320936703

Arthur, C. 2022. *Digitalization is driving entrepreneurship in Tunisia.* UNIDO. www.unido.org/stories/digitalization-driving-entrepreneurship-tunisia

Awasthi, A. 2022. *5 factors that are contributing towards digitisation of education*. India Today. https://www.indiatoday.in/education-today/featurephilia/story/5-factors-that-are-contributing-towards-digitisation-of-education-1947698-2022-05-12

Banga, K. and Te Velde, D.W. 2018. *Digitalisation and the Future of Manufacturing in Africa*. DIFD and ODI. Supporting Economic Transformation. https://set.odi.org/wp-content/uploads/2018/03/SET_Digitalisation-and-future-of-African-manufacturing_Final.pdf

Barasa, P.L. 2021. *Digitalization in teaching and education in Kenya: Digitalization, the future of work and the teaching profession project*. Geneva, International Labour Office. http://erepository.au.ac.ke/bitstream/handle/123456789/1312/wcms_783665.pdf?sequence=1andisAllowed=y

Barria, C. V. and Klasen, S. 2016. The impact of SENAI's vocational training program on employment, wages and mobility in Brazil: Lessons for Sub Saharan Africa? *The Quarterly Review of Economics and Finance,* Vol. 62, pp. 74–96. https://doi.org/10.1016/j.qref.2016.07.010

Bittman, T., Forest, J., Aoyama, H., Dawson, P., and Gill, B. 2021. *Gartner Predicts 2022: Driving Toward Digital Infrastructure Platforms*. Gartner. https://www.gartner.com/en/documents/4007208

Bizami, N. A., Tasir, Z., and Kew, S. N. 2023. Innovative pedagogical principles and technological tools capabilities for immersive blended learning: A systematic literature review. *Education and Information Technologies*, Vol. 28, pp. 1373–1425. https://doi.org/10.1007/s10639-022-11243-w

Boehner, M. 2017. *High Quality Teaching and Assessing in TVET: The Road to Enhanced Learning Outcomes*. Tertiary and Vocational Education Commission.

Boyle, E. A., Hainey, T., Connolly, T. M., Gray, G., Earp, J., Ott, M., Lim, T., Ninaus, M., Ribeiro, C., and Pereira, J. 2016. An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games. *Computers and Education*, Vol. 94, pp. 178–192. https://doi.org/10.1016/j.compedu.2015.11.003

Bozalek, V., Ng'ambi, D., Wood, D., Herrington, J., Hardman, J., and Amory, A. 2014. *Activity Theory, Authentic Learning and Emerging Technologies: Towards a transformative higher education pedagogy*. Routledge.

Bozkurt, A., Kilgore, W., and Crosslin, M. 2018. Bot-teachers in hybrid massive open online courses (MOOCs): A post-humanist experience. *Australasian Journal of Educational Technology*, Vol. 34(3), pp. 39–59. https://ajet.org.au/index.php/AJET/article/view/3273/1477

Bozkurt, A., Xiao, J., Lambert, S., Pazurek, A., Crompton, H., Koseoglu, S., Farrow, R., Bond, M., Nerantzi, C., Honeychurch, S., Bali, M., Dron, J., Mir, K., Stewart, B., Costello, E., Mason, J., Stracke, C. M., Romero-Hall, E., Koutropoulos, A., Toquero, C. M., Singh, L Tlili, A., Lee, K., Nichols, M., Ossiannilsson, E., Brown, M., Irvine, V., Raffaghelli, J. E., Santos-Hermosa, G Farrell, O., Adam, T., Thong, Y. L., Sani-Bozkurt, S., Sharma, R. C., Hrastinski, S., and Jandrić, P. 2023. Speculative Futures on ChatGPT and Generative Artificial Intelligence (AI): A Collective Reflection from the Educational Landscape. *Asian Journal of Distance Education*, Vol. 18(1), 2023, pp. 53–130. https://doi.org/10.5281/zenodo.7636568

Brazilian Ministry of Social Development. 2020. *Single Registration of the Municipality Pureza*. State Rio Grande do Norte.

Breckwoldt, J., Gruber, H., and Wittmann, A. 2014. *International handbook of research in professional and practice-based learning*. Springer. https://doi.org/10.1007/978-94-017-8902-8_25

Brito Nogueira, V., Gomes Teixeira, D., Cavalcante Nunes de Lima, I. A., Vinícius Chaves Moreira, M., Caixeta de Oliveira, B. S., Bezerra Pedrosa, I. M., Wilton de Queiroz, J., and Bezerra Jeronimo, S. M. 2022. Towards an inclusive digital literacy: An experimental intervention study in a rural area of Brazil. *Education and Information Technologies,* Vol. 27(2), pp. 2807–2834. https://doi.org/10.1007/s10639-021-10711-z

Broussard, M. 2019. *Artificial Unintelligence: How Computers Misunderstand the World.* Cambridge, Mass., USA, MIT Press.

Burning Glass Technologies. 2017. The digital edge: Middle-skill workers and careers. https://www.burning-glass.com/wp-content/uploads/Digital_Edge_report_2017_final.pdf

Carbonaro, M., King, S., Taylor, E., Satzinger, F., Snart, F., and Drummond, J. 2008. Integration of e-learning technologies in an interprofessional health science course. *Medical Teacher*, Vol. 30(1), pp. 25–33. https://doi.org/10.1080/01421590701753450

Carbonero, F., E. Ernst and E. Weber. 2018. Robots Worldwide: The Impact of Automation on Employment and Trade. *ILO Research Department Working Paper No. 36*. Geneva, International Labour Organization.

Castillo, D., Canhoto, A. I., and Said, E. 2021. The dark side of AI-powered service interactions: exploring the process of co-destruction from the customer perspective. The Service Industr*ies Journal,* Vol. 41, pp. 900–925. https://doi.org/10.1080/02642069.2020.1787993

CEDEFOP. 2022. Microcredentials for labour market education and training: first look at mapping microcredentials in European labour-market-related education, training and learning: take-up characteristics and functions. Thessaloniki, Greece, CEDEFOP. http://doi.org/10.2801/351271

Centeno, C., Karpinski, Z., and Urzi Brancati, M.C. 2022. *Supporting policies addressing the digital skills gap.* Joint Research Centre (European Commission). https://op.europa.eu/en/publication-detail/-/publication/f42b2b73-ba07-11ec-b6f4-01aa75ed71a1/language-en

Cha, H., Park, T., and Seo, J. 2020. What Should Be Considered when Developing ICT-Integrated Classroom Models for a Developing Country? *Sustainability*, Vol. 12(7). https://doi.org/10.3390/su12072967

Chaitra, J., Padmamalini., M., Anand., V., Vasudha., K; Roshmi., G., Zia S. P., Sharon., D., Chaithra D. A., Luci., K., Rohit., S., Santosh G. H., and Bhujang, S. 2020. Tele-consultations in the wake of COVID-19 – Suggested guidelines for clinical ophthalmology. *Indian Journal of Opthalmology,* Vol. 68(7), pp. 1316–1327. DOI: 10.4103/ijo.IJO_1509_20

Chakroun, B. and Keevy, J. 2023. *The evolution of credentials: a call to action to rethink the education, training, and work continuum*. Forthcoming. NORRAG.

Chandola, V. (2015). Digital Transformation and Sustainability: Study and Analysis. [Master's capstone, Harvard University].https://doi.org/10.13140/RG.2.1.3358.0567

Chen, J. (2017). Towards New and Multiple Perspectives on Innovation. *International Journal of Innovation Studies*, Vol. 1(1), pp. 1–4. https://doi.org/10.3724/SP.J.1440.101001

Chen, X., Zou, D., Xie, H., Cheng, G., and Liu, C. 2022. Two Decades of Artificial Intelligence in Education: Contributors, Collaborations, Research Topics, Challenges, and Future Directions. *Educational Technology & Society*, Vol. 25(1), pp. 28–47. https://doi.org/10.30191/ETS.202201_25(1).0003

Chowdhury, A. 2021 (December 25). Digital Bangladesh to Innovative Bangladesh: The road to 2041. UNDP. https://www.undp.org/bangladesh/blog/digital-bangladesh-innovative-bangladesh-road-2041

Colvard, N. B., Watson, C. E., and Park, H. 2018. The Impact of Open Educational Resources on Various Student Success Metrics. *International Journal of Teaching and Learning in Higher Education*, Vol. 30(2), pp. 262–276. https://files.eric.ed.gov/fulltext/EJ1184998.pdf

Crockett, E. 2023 (March 14). How AI is Being Used in Education. *Datamatic.* https://www.datamation.com/artificial-intelligence/how-ai-is-being-used-in-education/

Crosling, G., Atherton, G., and Lee Siew Hoong, A. 2022. TVET: Scaffolding digital skills to the future. *TVET.* https://tvetjournal.com/tvet-tools/tvet-digital-skills-frameworks/

Delaporte, A. and Bahia, K. 2022. The State of Mobile Internet Connectivity 2022. London, GSMA. https://www.gsma.com/r/somic/

De Freitas, S. 2018. Are Games Effective Learning Tools? A Review of Educational Games. *Educational Technology & Society*, Vol. 21(2), pp. 74–84.

De Melo, J. and Solleder, J-M. 2022 (May). Structural Transformation in MENA and SSA: The Role of Digitalization. *Economic Research Forum Working Paper No. 1547*. Doki, Giza, Egypt, Economic Research Forum. https://erf.org.eg/app/uploads/2022/05/1653590728_953_1578458_1547.pdf

Digital India Corporation, Ministry of Electronics and Information Technology. *DigiBunai CAD Software*. https://digibunai.dic.gov.in/index.php/about#about-software (Accessed January 07, 2023.)

Drake, J. R., O'Hara, M. T., and Seeman, E. (2015). Five principles for MOOC design: With a Case Study. *Journal of Information Technology Education: Innovations in Practice,* Vol. 14, pp. 125–143. https://doi.org/10.28945/2250

Ehlers, U-D. 2011. Extending the Territory: From Open Educational Resources to Open Educational Practices. *Journal of Open, Flexible and Distance Learning*, Vol. 15(2), pp. 1–10. https://www.jofdl.nz/index.php/JOFDL/article/view/64/46

Eloundou, T., Manning, S. and Rock, D. 2023. GPTs are GPTs: An Early Look at the Labor Market Impact. Potential of Large Language Models. Working Paper, Cornell University. https://arxiv.org/pdf/2303.10130.pdf

El-Hussein, M. O. M. and Cronje, J. C. 2010. Defining Mobile Learning in the Higher Education Landscape. *Educational Technology & Society*, 13*(3)*, 12–21.

Ericsson, K. A. 2004. Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Academic Medicine*, *79*(10), S70–S81. http://doi.org/10.1097/00001888-200410001-00022

European Software Skills Alliance. 2021. *Europe's most needed software roles and skills: Needs analysis report.* https://www.softwareskills.eu/wp-content/uploads/2022/10/D.4_ESSA_Europeâ__s-Most-Needed-Software-Roles-and-Skills.-Needs-Analysis-Report_FINAL-draft.pdf

European Training Foundation. 2019. *Continuing professional development for vocational trainers in Tunisia 2018: Culture, teaching practices, professional duties, working conditions, beliefs and professionalisation.* https://openspace.etf.europa.eu/sites/default/files/2019-10/Tunisia%20CPD%20survey%202018_EN.pdf

Farliana, N. and Mulyono, K. B. 2018. Development of Blended Learning Model Based on Constructivism of Conservation Value. *KnE Social Sciences*, Vol. 3(10), pp. 731–746. https://doi.org/10.18502/kss.v3i10.3168

Firestone, R., Schott, B., Omollo, A., Agarwal, S., Pfeil, H., Johns, K. and Kumagai, S. 2017. Citizen service centers in Kenya : the role of Huduma Centers in advancing citizen-centered service delivery in a context of devolution and digitization. New York: World Bank. https://documents.worldbank.org/pt/publication/documents-reports/documentdetail/971401498753976220/citizen-service-centers-in-kenya-the-role-of-huduma-centers-in-advancing-citizen-centered-service-delivery-in-a-context-of-devolution-and-digitization

Foko, T. and Amory, A. 2008 (January). Social constructivism in games-based learning in the South African context [Paper presentation]. *ED-MEDIA 2008--World Conference on Educational Multimedia, Hypermedia & Telecommunications.* Vienna, Austria. https://www.researchgate.net/publication/277751805_Social_Constructivism_in_Games_Based_Learning_in_The_South_African_Context?enrichId=rgreq-fe5f7951b58af5f6013a1571577ba453-XXX&enrichSource=Y292ZXJQYWdlOzI3Nzc1MTgwNTtBUzo3NzIxNDI1NTE1MzU2MTlAMTU2MTEwNDUzODkzOA%3D%3D&el=1_x_2&_esc=publicationCoverPdf

Ford, S. and Minshall, T. (2019). Invited review article: Where and how 3D printing is used in teaching and education. *Additive Manufacturing*, *25*, 131–150. https://doi.org/10.1016/j.addma.2018.10.028

Garzón, J., Pavón, J., and Baldiris, S. 2019. Systematic review and meta-analysis of augmented reality in educational settings. *Virtual Reality*, Vol. 23, pp. 447–459. https://doi.org/10.1007/s10055-019-00379-9

GIZ. 2019. *Solar energy in Tunisia: Vocational training for experts*. Deutsche Gesellschaft für Technische Zusammenarbeit. https://www.giz.de/en/mediacenter/74675.html

Golman, M. and Ernst, C. 2022. *Future of Work, Emerging Sectors and the Potential for Transition to Formality*. Geneva, International Labour Organization. https://www.ilo.org/employment/units/emp-invest/informal-economy/WCMS_855420/lang--en/index.htm

Gomez, J. and Lorini, M. R. (eds.). 2022. *Digital Transformation for Sustainability: ICT-supported Environmental Socio-economic Development*. Springer International Publishing.

Gonzalez, J., Carcia, S. and Pichardo, I. 2015. Strategies of collaborative work in the classroom through the design of video games. *Digital Education Review*, 27, June 2015, pp. 69-84. https://files.eric.ed.gov/fulltext/EJ1064985.pdf

Goppold, M., Frenz, M., and Nitsch, V. 2022. User feedback of apprentices on an augmented reality system for learning from errors in TVET. In C. Nägele, N. Kersh, & B. E. Stalder (Eds.), Trends in vocational education and training research, Vol. V. Proceedings of the European Conference on Educational Research (ECER), Vocational Education and Training Network (VETNET) (pp. 44–54). https://doi.org/10.5281/zenodo.6975374

Grant Thornton. 2020. Skilling ecosystem in India: Unlocking the potential of youth. https://www.grantthornton.in/globalassets/1.-member-firms/india/assets/pdfs/skilling-ecosystem-in-india-unlocking-the-potential-of-youth.pdf

Grundke, R. and Cassimon, S. 2022. Improving skills and employment opportunities in Tunisia. *OECD Economics Department Working Papers*, No. 1727. Paris, OECD Publishing. https://doi.org/10.1787/51e7a341-en

Hassan, R. H., Hassan, M. T., Naseer, S., Khan, Z., and Jeon, M. 2021. ICT enabled TVET education: A systematic literature review. *IEEE Access*, Vol. 9, pp. 81624–81650. https://doi.org/10.1109/access.2021.3085910

HEART/NSTA TRUST. 2021. *Human Development and Resource Training/National Service Training Agency Trust*. Kingston, Jamaica, HEART/NSTA Trust. https://www.heart-nsta.org/wp-content/uploads/HEART2021AnnualReport.pdf

Hemmings-Jarrett, K., Jarrett, J., Hylton, J., Williams, S., and Campbell, Y. 2022. *A Preliminary Examination of Power Relationships' Influence on Reducing the Digitally Marginalized Student Population in Jamaica*. Americas Conference on Information Systems (AMCIS) at AIS Electronic Library (AISeL).

Holzinger, A., Weippl, E., Tjoa, A. M., and Kieseberg, P. 2021. *Digital Transformation for Sustainable Development Goals (SDGs) - A Security, Safety and Privacy Perspective on AI* [Paper presentation]. International Cross-Domain Conference, CD-MAKE 2021. https://doi.org/10.1007/978-3-030-84060-0_1

Idrissi, M., Hnida, M., and Bennani, S. 2016. Competency-Based Assessment: From Conceptual Model to Operational Tool. In: *Eds. Cano, E & Ion, G. Innovative Practices for Higher Education Assessment and Measurement. IGI Global: Hershey, Pennsylvania*. 10.4018/978-1-5225-0531-0

International Labour Organization. 2019. *State of Skills: Tunisia*. Geneva, International Labour Organization. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/genericdocument/wcms_736691.pdf

––. 2020a. *The Digitization of TVET and Skills Systems.* Geneva, International Labour Organization. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_752213.pdf

––. 2020b. *State of Skills*: *Tunisia.* Geneva, International Labour Organization. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/genericdocument/wcms_736691.pdf

––. 2021a. *Digitalization of national TVET and skills systems: Harnessing technology to support LLL: An enquiry and action framework*. Geneva, International Labour Organization. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_826682.pdf

––. 2021b. *Digitalisation of TVET and skills development: leveraging technology to support lifelong learning*. Geneva, International Labour Organization. http://hdl.voced.edu.au/10707/599827

––. 2021c. *Skills development in the time of COVID-19: Taking stock of the initial responses in technical and vocational education and training*. Geneva, International Labour Organization. https://www.ilo.org/skills/areas/skills-training-for-poverty-reduction/WCMS_766557/lang--en/index.htm

––. 2021d. *Changing demand for skills in digital economies and societies: Literature review and case studies from low- and middle-income countries*. Geneva, International Labour Organization. www.ilo.org/wcmsp5/groups/public/---ed_emp/---ifp_skills/documents/publication/wcms_831372.pdf

––. 2022. *Digitalization and Employment*. Geneva, International Labour Organization. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/publication/wcms_854353.pdf

International Labour Organization and UNICEF. 2023. *Global Research on the Labour Market Value of Microcredentials with a Focus on Youth Employment*. Forthcoming. Geneva and New York, ILO and UNICEF.

International Telecommunication Union. 2019. *Measuring digital development: Facts and figures 2019*. Geneva, ITUPublications. https://www.itu.int/en/ITU-D/Statistics/Documents/facts/FactsFigures2019.pdf

International Telecommunication Union, UNESCO and UNICEF. 2020. T*he Digital Transformation of Education. Connecting Schools, Empowering Learners*. ITU, UNESCO and UNICEF. https://www.unicef.org/media/111621/file/TheStateoftheGlobalEducationCrisis.pdf.pdf

Karstensen, S. and Lier, A. 2020. Virtual welding: A didactic perspective. *Nordic Journal of Vocational Education and Training*, 2020, pp. 95-107. https://www.researchgate.net/publication/342042308_Virtual_welding_A_didactic_perspective

Keevy, J., Castel-Branco, E., Bateman, A., Vally, Z., Overeem, M., Mavimbela, L., Adotevi, J., Sutherland, L., Matlala, R., Kyari, U.F. and Sibiya, T. Turin. 2021. *Mapping Report: Towards the African Continental Qualifications Framework*. European Training Foundation and Deutsche Gesellschaft für Internationale Zusammenarbeit. https://acqf.africa/resources/mapping-study/acqf-mapping-report-comprehensive/@@display-file/file/ACQF%20EN_Mapping%20Report_WEB_2.pdf

Khan, U., Hameed, Z., Yu, Y., Islam, T., Sheikh, Z., and Ullah Khan, S. 2018. Predicting the acceptance of MOOCs in a developing country: Application of task-technology fit model, social motivation, and self-determination theory. *Telematics and Informatics,* Vol. 35(4), pp. 964–978. https://doi.org/10.1016/j.tele.2017.09.009

Kolb, D. A. 2015. *Experiential learning: Experience as the source of learning and development*. Pearson Education, Inc.

Kumar, K. and Kaur, G.P. 2022. Bridging the digital divide: Push digitalisation of TVET and industry 4.0 skills, Hindustan Times. https://www.hindustantimes.com/opinion/bridging-the-digital-divide-push-digitalisation-of-tvet-and-industry-4-0-skills-101652608598343.html

Kurtz, G., Kopolovich, O., Segev, E., Sahar-Inbar, L., Gal, L., and Hammer, R. 2022. Impact of an Instructor's Personalized Email Intervention on Completion Rates in a Massive Open Online Course (MOOC). *Electronic Journal of e-Learning,* Vol. 20(3), pp. 325–335. https://doi.org/10.34190/ejel.20.3.2376

Latchem, C. (ed.). 2017. *Using ICTs and Blended Learning in Transforming TVET. Perspectives on Open and Distance Learning*. UNESCO and Commonwealth of Learning. https://oasis.col.org/colserver/api/core/bitstreams/d02a6e45-5dbd-4198-a7f3-6c696399d844/content

Lave, J. and Wenger, E. 1991. *Situated learning: Legitimate peripheral participation*. Cambridge University Press. https://doi.org/10.1017/CBO9780511815355

Lee, S., Atherton, G., and Crosling, G. 2022. *TVET teachers for the Fourth Industrial Age: Digital competency frameworks*. Bonn, UNESCO-UNEVOC. https://unevoc.unesco.org/up/TVET_Teachers_for_the_Fourth_Industrial_Age.pdf

Levin, V., Santos, I. V., Weber, M., and Hoftijzer, M. A. 2020. *TVET Systems' response to COVID-19: Challenges and Opportunities (English)* (Report No. 148495). Washington, DC, World Bank Group. http://documents.worldbank.org/curated/en/930861589486276271/TVET-Systems-response-to-COVID-19-Challenges-and-Opportunities

Luo, X. 2019. E-commerce for poverty alleviation in rural China: from grassroots development to public-private partnerships. Geneva, World Bank Group. https://blogs.worldbank.org/eastasiapacific/e-commerce-poverty-alleviation-rural-china-grassroots-development-public-private-partnerships

Masriadi, Dasmadi, Ekaningrum, N., Hidayat, M. and Yuliaty, F. (2023). Exploring the Future of Work: Impact of Automation and Artificial Intelligence on Employment. ENDLESS: *International Journal of Future Studies*, Vol. 6 No. 1 (2023), pp. 125-136. https://www.researchgate.net/publication/368693016_Exploring_the_Future_of_Work_Impact_of_Automation_and_Artificial_Intelligence_on_Employment

Mazin, K. A., Norman, H., Nordin, N., and Ibrahim, R. 2020. MOOC Student Learning Analytics For Automotive Technology Programme In Vocational College. *Journal of Physics: Conference Series,* pp. 1–11. https://doi.org/10.1088/1742-6596/1529/5/052075

Mazrui, A. and Wagaw, T. 1985. Towards decolonizing modernity: education and culture conflict in Eastern Africa. In *The Educational Process and Historiography in Africa*, pp. 35–62. Paris, UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000067129

McKinsey and Company. 2022. McKinsey Technology Trends Outlook 2022. Research overview. https://www.mckinsey.com/~/media/mckinsey/business%20functions/mckinsey%20digital/our%20insights/the%20top%20trends%20in%20tech%202022/mckinsey-tech-trends-outlook-2022-full-report.pdf

McKinsey Global Institute. 2019. Digital India Technology to transform a connected nation. McKinsey & Company. https://www.mckinsey.com/~/media/mckinsey/business%20functions/mckinsey%20digital/our%20insights/digital%20india%20technology%20to%20transform%20a%20connected%20nation/mgi-digital-india-report-april-2019.pdf

merSETA. 2020. *Final Sector Skills Plan Update 2021/ 2022*. Manufacturing, Engineering, and Related Services SETA. https://www.merseta.org.za/wp-content/uploads/2021/04/Sector-Skills-Plan-2021-22.pdf

Ministry of Education and Youth. 2022. *ICT in Education Policy.* Government of Jamaica, Ministry of Education and Youth. https://moey.gov.jm/wp-content/uploads/2022/07/ICT-in-Education-Policy-Jamaica-Ministry-of-Education-and-Youth-2022.pdf

Ministry of Electronics and IT in India. 2022. Achievements Made under Digital India Programme. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1885962

Ministry of Finance. 2013. *The Gazette Of India Extraordinary, Part 1, Section 2. Ministry Of Finance. Department of Economic Affairs.* Government of India, Ministry of Finance. https://www.education.gov.in/sites/upload_files/mhrd/files/NSQF%20NOTIFICATION.pdf

Ministry of Skill Development and Entrepreneurship. 2019. *Skill Saathi Counselling Scheme Guidelines 2018-19*. Government of India, Ministry of Skill Development and Entrepreneurship. https://www.msde.gov.in/sites/default/files/2019-12/Skill-Saathi-Guidelines.pdf

Muriuki, S. and Dominic, M. 2022. Retraining TVET Trainers in Kenya for Changing Global Trends and Dynamics. *Africa Journal of Technical and Vocational Education and Training,* Vol. 7(1), pp. 61–75. http://afritvetjournal.org/index.php/Afritvet/article/view/140

Musyimi, C. 2021. Developing Skills to Unlock Kenya's Industrial Growth: The Influence of Provision of Modern Teaching and Learning Equipment in TVET in Kenya. *Journal of Learning and Development*, Vol. 8, pp.182-191. https://jl4d.org/index.php/ejl4d/article/view/414/593

National Credit Framework. 2022. *Draft Report of National Credit Framework: The Report of the High-Level Inter-Ministerial Committee on National Credit Accumulation & Transfer Framework*. National Credit Framework. https://dsel.education.gov.in/sites/default/files/update/National_Credit_Framework.pdf

Ndulu, B., Joseph, C. and Tryphone, K. (2021). Fiscal Regimes and Digital Transformation in Sub-Saharan Africa. *Digital Pathways Paper Series*. DOI: https://doi.org/10.35489/BSG-DP-WP_2021/01Digital Nedelkoska, L. and G. Quintini. 2018. Automation, Skills Use and Training. *OECD Social, Employment and Migration Working Papers*, No. 202. Paris, OECD Publishing. http://dx.doi.org/10.1787/2e2f4eea-en

Nogueira Barros, J., Pineda Nebot, C., and Pinheiro de Andrade, H. 2018. The National Plan of education Brazilian (2014-2024) and challenges for local development. *Research, Society and Development*, Vol. 7(4), pp. 1–21. https://rsdjournal.org/index.php/rsd/article/view/225/199

OECD and World Bank. 2022. *How Learning Continued during the COVID-19 Pandemic: Global Lessons from Initiatives to Support Learners and Teachers*. OECD Publishing, Paris, https://doi.org/10.1787/bbeca162-en.

Odondi, W., Arisa, K., and Wangari, V. 2022. Digital Literacy Capabilities of TVET Institutions for the Future of Work. *Africa Journal of Technical and Vocational Education & Training,* (Vol. 7(1), pp. 43–52. http://www.afritvetjournal.org/index.php/Afritvet/article/view/138/152

Odondi, W., Mukiria, F., and Wawira, B. 2022. Building Resilient TVET Institutions in Kenya amid the COVID-19 Pandemic. *Africa Journal of Technical and Vocational Education and Training*, Vol. 7(1), pp. 137–146. http://www.afritvet.org/index.php/Afritvet/article/view/146/161

Onyango, G. and Ondiek, J, 2021. Digitalization and Integration of Sustainable Development Goals (SGDs) in Public Organizations in Kenya. *Public Organization Review* (2021) 21, pp. 511–526. https://cfs.uonbi.ac.ke/system/files/2022-08/Gedion%20Onyango%20-%20Digitalisation%20and%20Integration%20of%20SDGs%20in%20Public%20Organisations%20in%20Kenya.pdf

Ozdemir, M., Sahin, C., Arcagok, S. and Demir, M. 2018. The Effect of Augmented Reality Applications in the Learning Process: A Meta-Analysis Study. *Eurasian Journal of Educational Research*, 74, 2018, pp. 165-186. https://www.researchgate.net/publication/324210750_The_Effect_of_Augmented_Reality_Applications_in_the_Learning_Process_A_Meta-Analysis_Study

Pan, Z., Cheok, A. D., Yang, H., Zhu, J., and Shi., J. 2006. Virtual reality and mixed reality for virtual learning environments. *Computers & Graphics*, Vol. 30(1), pp. 20–28. https://doi.org/10.1016/j.cag.2005.10.004

Parmentola, A., Petrillo, A., Tutore, I., and De Felice, F. 2021. Is blockchain able to enhance environmental sustainability? A systematic review and research agenda from the perspective of Sustainable Development Goals (SDGs). *Business Strategy and the Environment*, Vol. 31, pp. 194-217. https://doi-org.ezproxy.uct.ac.za/10.1002/bse.2882

Pennathur, A. K. 2001. "Clicks and bricks": e-Risk Management for banks in the age of the Internet. *Journal of Banking & Finance,* Vol. 25(11), pp. 2103–2123. https://doi.org/10.1016/S0378-4266(01)00197-2

Ravindran, B., Garg A., and Bhasin, S. 2022. How can India Transition to Sustainable Cooling? Council on Energy, Environment and Water Blog. https://www.ceew.in/blogs/how-can-india-lead-sustainable-climate-friendly-cooling

Reeves, T. C., Herrington, J., and Oliver, R. 2004. A development research agenda for online collaborative learning. *Educational Technology Research and Development*, Vol. 52, pp. 53–65. https://doi.org/10.1007/BF02504718

Reeves, T. C. and McKenney, S. 2015. *Design-based research.* (Spector, J. M., ed.). SAGE Publications, Inc. https://doi.org/10.4135/9781483346397.n83

Rehman, A., Saba, T., Kashif, M., Fati, S. M., Bahaj, S. A., and Chaudhry., H. 2022. A Revisit of Internet of Things Technologies for Monitoring and Control Strategies in Smart Agriculture. *Agronomy*, Vol. 12(1), pp. 1–27. https://doi.org/10.3390/agronomy12010127

Reinitz, B. (2020, June 1). Consider the three Ds when talking about digital transformation. *Educause Review*. https://er.educause.edu/blogs/2020/6/consider-the-three-ds-when-talking-about-digital-transformation

Republic of Kenya. 2012. 2013/14-2015/16. Medium Term Expenditure Framework. https://www.education.go.ke/sites/default/files/2022-05/Education-Sector-Report-FY-2013-14.pdf

Republic of Kenya.Ministry of Information, Communications and the Digital Economy. 2021. Policy on Information and Communication Technology in Education and Training. https://www.education.go.ke/sites/default/files/2023-01/ICT%20IN%20EDUCATION%20AND%20TRAINING%20POLICY%202021.pdf

Rowe, P. G. (1998). *Design thinking*. Cambridge, MIT Press.

Rujira, T., Nilsook, P., and Wannapiroon, P. (2020). Synthesis of Vocational Education College Transformation Process toward High-Performance Digital Organization. *International Journal of Information and Education Technology*, Vol. 10(11), pp. 832–837. https://doi.org/10.18178/ijiet.2020.10.11.1466

Rynes, S. L., Bartunek, J. M., and Daft, R. L. 2001. Across the great divide: Knowledge creation and transfer between practitioners and academics. *Academy of Management Journal,* Vol. 44(2), pp. 340–355.

Sapra, B. 2022. A startup from Tataouine takes AI global. *Wired*. https://wired.me/business/big-tech/tunisia-instadeep-ai-inner-circle/

Schmitt, J., Shierholz, H. and Mishel, L. (2013). Don't Blame the Robots. Assessing the Job Polarization Explanation of Growing Wage Inequality. Economic Policy Institute, Washinton DC. https://www.epi.org/publication/technology-inequality-dont-blame-the-robots/

Shah, V., Murthy, S., Warriem, J., Sahasrabudhe, S., Banerjee, G., and Iyer, S. 2022. Learner-centric MOOC model: A pedagogical design model towards active learner participation and higher completion rates. *Educational Technology Research and Development*, Vol. 70, pp. 263–288. https://doi.org/10.1007/s11423-022-10081-4

Shanahan, M. 2022. *The Mobile Gender Gap Report 2022*. London, GSMA. https://www.gsma.com/r/wp-content/uploads/2022/06/The-Mobile-Gender-Gap-Report-2022.pdf?utm_source=website&utm_medium=download-button&utm_campaign=gender-gap-2022

Sharples, M., Taylor, J., and Vavoula, G. 2016. A Theory of Learning for the Mobile Age. https://www.researchgate.net/publication/343099651_A_Theory_of_Learning_for_the_Mobile_Age

Shiohira, K., and Dale-Jones, B. 2019. *Interoperable data ecosystems: An international review to inform a South African innovation*. JET Education Services and merSETA. https://www.jet.org.za/resources/interoperable-data-ecosystems.pdf

Sjodin, D., Parida, V., Palmie, M., and Wincent, J. 2021. How AI capabilities enable business model innovation: Scaling AI through co-evolutionary processes and feedback loops. *Journal of Business Research,* Vol. 134, pp. 574–587. https://doi.org/10.1016/j.jbusres.2021.05.009

Smith, T. 2016. Make Space for Indigeneity: Decolonizing Education. *SELU Research Review Journal,* Vol. 1(2), pp. 49–60.

Soeharto. 2019. Constructivist Approach for Vocational Education. *Advances in Social Science, Education and Humanities Research*, Vol. 440, pp. 257–260. https://doi.org/10.2991/assehr.k.200521.056

Sørensen, K., Aring, M., Hansen, A., Abidi, F., Diener, O., and Ouma, N. 2017. *Reforming Technical and Vocational Education and Training in Tunisia: Strategic Assessment.* AUP Report. https://simtunisie.weebly.com/uploads/1/8/1/2/18128835/aup_tunisia_tvet_assessment_final.pdf

Sourmelis, T. S., Ioannou, A., and Zaphiris, P. 2017. Massively Multiplayer Online Role Playing Games (MMORPGs) and the 21st century skills: A comprehensive research review from 2010 to 2016. *Computers in Human Behavior*, Vol. 67, pp. 41–48. https://doi.org/10.1016/j.chb.2016.10.020

Stenberg, A. 2017. What does Innovation mean – a term without a clear definition. University of Halmstad. https://www.diva-portal.org/smash/get/diva2:1064843/FULLTEXT01.pdf

Stöhr, C. 2017. Anywhere and anytime? An analysis of the use of mobile devices in MOOCs. Conference: The Annual International Technology, Education and Development Conference INTED2017 at Valencia, Spain. Vol. 11. DOI:10.21125/inted.2017.2107

Stracke, C. M. 2017. The Quality of MOOCs: How to Improve the Design of Open Education and Online Courses for Learners? [Paper presentation]. International Conference on Learning and Collaboration Technologies. Vancouver, BC, Canada. https://doi.org/10.1007/978-3-319-58509-3_23

Thang Tze Yian, T. and Park, J. 2017. *Beyond access: ICT-enhanced innovative pedagogy in TVET in the Asia-Pacific*. UNESCO. https://en.unesco.org/sites/default/files/ict-enhanced_innovative_pedagogy_in_tvet_in_the_asia_pacific.pdf

Toffel, M. W., Mendelson, R., and Kelley, J. 2021. *Student Success at Georgia State University (A)*. Harvard Business School. https://hbsp.harvard.edu/product/621006-PDF-ENG

Trenerry, B., Chng, S., Wang, Y., Suhaila, Z. S., Lim, S. S., Lu, H. Y., and Oh, P. H. 2021. Preparing workplaces for digital transformation: An integrative review and framework of multi-level factors. *Frontiers in Psychology*, Vol. 12. https://doi.org/10.3389/fpsyg.2021.620766\

Tripney, J.S., and Hombrados, J.G. 2013. Technical and vocational education and training (TVET) for young people in low- and middle-income countries: a systematic review and meta-analysis. *Empirical Research in Vocational Education and Training*, Vol. 5, pp. 1-14. https://doi.org/10.1186/1877-6345-5-3

Tüzün, H., Barab, S. A., and Thomas, M. K. 2019. Reconsidering the motivation of learners in educational computer game contexts. *Turkish Journal of Education*, Vol. 8(2), pp. 129–159. https://doi.org/10.19128/turje.546283

UNESCO. 2018. *Digital Inclusion for Low-skilled and Low-literate People. A Landscape Review*. Paris, UNESCO. https://en.unesco.org/icted/content/digital-inclusion-low-skilled-and-low-literate-people

––. 2021. *Reimagining our futures together. A new social contract for education*. Paris, UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000379707.locale=en

––. 2022a. Policy brief: Digital transformation in education in Asia Pacific [Paper presentation]. 2nd Asia-Pacific Regional Education Minister's Conference (APREMC-II). Bangkok, Thailand. https://bangkok.unesco.org/content/policy-brief-digital-transformation-education-asia-pacific

––. 2022b. *Transforming Technical and Vocational Education and Training for successful and just transitions: UNESCO strategy 2022-2029*. Paris, UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000383360

––. 2022c. *Education in Latin America and the Caribbean at a crossroads: Regional monitoring report SDG4 - Education 2030*. Paris, UNESCO. https://en.unesco.org/sites/default/files/full_report_regional_monitoring_report_sdg4-e2030.pdf

––. 2022d. *Education and blockchain*. UNESCO and Commonwealth of Learning. Paris, UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000384003

––. 2023a. *Education in Africa: Placing equity at the heart of policy*. Paris, UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000384497

––. 2023b. *Learner-centred teaching in technical and vocational education and training: perspectives and reviews of six Asia-Pacific Countries*. Paris, UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000384610

––. 2023c. *Transforming education together. The Global Education Coalition in action*. Paris, UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000384812

––. n.d. *Digital Transformation Collaborative. Global Education Coalition.* Overview summary. Paris, UNESCO.

UNESCO and Mila. 2023. Missing links in AG governance. UNESCO/Mila – Québec Institute of Artificial Intelligence. https://unesdoc.unesco.org/ark:/48223/pf0000384787

UNESCO-UNEVOC. 2012. *World TVET Database Jamaica*. Bonn, UNESCO-UNEVOC. https://unevoc.unesco.org/wtdb/worldtvetdatabase_jam_en.pdf

–– n.d. *Digital Transformation in TVET: Supporting TVET providers for a digital world.* Bonn, UNESCO-UNEVOC. https://unevoc.unesco.org/home/Digital+Transformation+in+TVET

––. 2020a. TVET Country Profiles: Tunisia. Bonn, UNESCO-UNEVOC. https://unevoc.unesco.org/home/Dynamic+TVET+Country+Profiles/country=TUN

––. 2020b. *Promoting quality in TVET using technology. A practical guide*. Bonn, UNESCO-UNEVOC. https://unevoc.unesco.org/home/UNEVOC+Publications/lang=en/akt=detail/qs=6404

––. 2022. *Trends mapping study: Digital skills development in TVET teacher training.* Bonn, UNESCO-UNEVOC. https://unevoc.unesco.org/pub/trends_mapping_study_digital_skills_development_in_tvet_teacher_training.pdf.

UNESCO-UNEVOC and National Council for the Federal Network of Vocational Institutions (CONNIF). 2018. *TVET Country Profile: Brazil.* Bonn, UNESCO-UNEVOC. https://unevoc.unesco.org/wtdb/worldtvetdatabase_bra_en.pdf

UNESCO-UNEVOC. 2020a. *TVET Country Profiles: Brazil*. Bonn, UNESCO-UNEVOC. https://unevoc.unesco.org/home/Dynamic+TVET+Country+Profiles/country=BRA

UNESCO-UNEVOC. 2020b. *TVET Country Profiles: India*. Bonn, UNESCO-UNEVOC. https://unevoc.unesco.org/home/Dynamic+TVET+Country+Profiles/country=IND

UNESCO-UNEVOC. 2020c. *TVET Country Profiles: Kenya*. Bonn, UNESCO-UNEVOC. https://unevoc.unesco.org/home/Dynamic+TVET+Country+Profiles/country=KEN

UNESCO-UNEVOC. 2020d. *TVET Country Profiles: Jamaica*. Bonn, UNESCO-UNEVOC. https://unevoc.unesco.org/home/Dynamic+TVET+Country+Profiles/country=JAM

UNESCO-UNEVOC. 2020e. T*VET Country Profiles: Tunisia*. Bonn, UNESCO-UNEVOC. https://unevoc.unesco.org/home/Dynamic+TVET+Country+Profiles/country=TUN

United Nations. 2020. *World youth report: Social entrepreneurship and the 2023 agenda*. New York, United Nations, Department of Economic and Social Affairs. https://www.un.org/development/desa/youth/wp-content/uploads/sites/21/2020/07/2020-World-Youth-Report-FULL-FINAL.pdf

Wiggins, G. 2011. A True Test: Toward More Authentic and Equitable Assessment. *Phi Delta Kappan,* Vol. 92(7), pp. 81–93. https://doi.org/10.1177/003172171109200721

World Bank. 2016. *Digital Dividends. World Bank Development Report*. Washington, DC, The World Bank.

––. 2021a. *GovTech Maturity Index: The State of Public Sector Digital Transformation in the public sector.* Washington, DC, The World Bank. https://documents1.worldbank.org/curated/en/495831623303257484/pdf/GovTech-Maturity-Index-The-State-of-Public-Sector-Digital-Transformation.pdf

––. 2021b. Covid-19 and the Future of Work in Africa: Emerging Trends in Digital Technology Adoption. In: *Africa's Pulse: An Analysis of Issues Shaping Africa's Economic Future, An Analysis of Issues Shaping Africa's Economic Future*, Vol. 23. Washington, DC, International Bank for Reconstruction and Development and The World Bank. http://www.indiaenvironmentportal.org.in/files/file/africa%20pulse%20april%202021.pdf

Xing, W. 2019. Exploring the Influences of MOOC Design Features on Student Performance and Persistence. *Distance Education*, Vol. 40(1), pp. 98–113. https://doi.org/10.1080/01587919.2018.1553560

Youssef, A.B. 2021. Digital transformation in Tunisia: Under which conditions could the digital economy benefit everyone? *The Economic Research Forum (ERF) Working Paper No. 151*. Doki, Giza, Egypt, Economic Research Forum. https://erf.org.eg/app/uploads/2021/11/1637495187_570_734598_1512.pdf

Youssef, A. B., Dahmani, M., and Ragni, L. 2022. ICT Use, Digital Skills and Students' Academic Performance: Exploring the Digital Divide. *Information*, Vol. 13(3), pp. 129. https://doi.org/10.3390/info13030129

Zhao, W., Queralta, J. P., and Westerlund, T. 2020. Sim-to-Real Transfer in Deep Reinforcement Learning for Robotics: a Survey. *2020 IEEE Symposium Series on Computational Intelligence* (SSCI), Canberra, Australia, ACT, pp. 737–744. https://doi.org/10.1109/SSCI47803.2020.9308468

unesco
United Nations
Educational, Scientific
and Cultural Organization

Enhancing TVET through digital transformation in developing countries

Technological advancements and digitalization are profoundly reshaping our work and lifestyle, business models and operations, and government policy choices. Digital transformation in technical and vocational education and training (TVET) is the planned and structured introduction of automated and streamlined processes within institutions and national technical and vocational education and training (TVET) systems through digital technology, with the goal of enhancing their scope, scale, efficiency and effectiveness and ultimately, driving their more sustainable development.

This document provides overall perspective and five country case studies on digital transformation in TVET. Most countries studied face similar enabling factors: the digital infrastructure available; legal and policy frameworks; focused institutional change to improve the acquisition of digital skills; and the promotion of equality and inclusivity. To understand how digital transformation in TVET is occurring, the report analyses it at four levels: technical and technological development; curriculum and qualifications; teaching and learning using technology; and its contribution to the sustainability and resilience of societies

Stay in touch

infostvet@unesco.org

www.unesco.org

UNESCO
7, place de Fontenoy
75352 Paris France

Follow @UNESCO on social media

4 QUALITY EDUCATION

Sustainable Development Goals